Energy Efficiency and Renewable Energy in Appalachia: Policy and Potential

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FINAL REPORT

Prepared for:

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Executive Summary

The Appalachian Regional Commission (ARC) contracted the Center for Business and Economic Research at Marshall University to perform a study to accomplish:

- A review of existing information regarding the availability of alternate and renewable energy resources in the ARC states
- A synopsis of the policies used in ARC states to promote the use of alternate and renewable energy as well as those to promote energy efficiency
- A discussion of energy intensity and how it is measured in the counties in the ARC region
- An overview of successful projects in the ARC region using alternate and renewable energy in addition to examples of significant improvements in energy efficiency that had positively impacted the firms which introduced them

Alternative and Renewable Energy Resources

The ARC region is blessed with an abundance of alternative and renewable energy resources. These can be developed not only to reduce the nation's dependence on imported energy and create positive environmental benefits, but to create jobs and build stronger economies in ARC counties. Almost all of these are in the early stages of development and commercialization. Some must await the further development of technology. Seeing the promotion and development of alternate and renewable energy would be a desirable policy for all ARC states.

The distribution of these resources varies widely across the ARC which means a variety of programs and policies should be developed in each state and sub-region to maximize the use of those resources most abundant in their area. A single policy which promotes one resource over another will not maximize the potential for the region.

- <u>Wind power</u> is significantly underdeveloped in the region. Many researchers see it as having the greatest promise as the technology is mature and the environmental benefits appear to outweigh the costs. Potential lies along the ridge lines of the mountains and, while not in the ARC region, offshore as well. There are numerous examples of successful wind farms in addition to small scale projects at residential and commercial facilities already operating in the region.
- <u>Solar power</u> does not hold as great a potential in the ARC as it does elsewhere in the nation. Technology and cost are impediments as is the moderate to low solar capacity of the region. Residential and commercial applications are solar energy's best options but subsidization will be required for widespread adoption in the near-tem.
- <u>Geotherma</u>l has potential for expanded direct use of heat from subsurface air and water for heating and cooling. There is little variation in geothermal capability in the region and the low temperatures are not conducive to electrical generation.
- <u>Biomass</u> from a variety of sources (crop residues, methane emissions, wood and forest waste, dedicated energy crops and livestock waste) is one of the most

promising alternatives. There is considerable biomass potential throughout the region and there are already impressive applications being made in most ARC states. Chicken litter and cow manure are receiving attention because of their availability in much of the ARC region and their negative effects on water pollution. While there is potential for energy production from this waste most of the use would be on site. In addition to serving as a fuel, litter and manure produce fertilizer for which there is a growing market.

- <u>Small and low impact hydroelectric</u> remains underdeveloped despite its great potential. The pattern of rivers and watersheds creates numerous opportunities for small and low-flow hydro installations. The development of low impact hydro systems reduces the negative impacts often associated with hydropower installations. Small scale hydro can be used on site as well as being made available to the grid. Full utilization of this resource may be restricted by State riparian rights laws.
- <u>Biofuels</u> are also a very promising source of alternate energy for ARC utilization. The development of biofuels including ethanol and bio-diesel is proceeding rapidly and promises to become a significant replacement or supplement of conventional petroleum based fuels. The demand for transportation fuel is not going to recede in the future. The numerous sources from which bio-fuels can be produced make this an exceptional option. The use of switchgrass in the southern portions of the region should be encouraged. The market for biofuels will be enhanced as distribution becomes more widely available.

State Policies Promoting Use of Renewable Energy, Alternate Energy and Energy Efficiency

Recent years have seen **comprehensive energy plans** either passed or under consideration in New York, Georgia, Kentucky, North Carolina, Virginia and West Virginia. All of these have similar provisions but emphasize different approaches. These include:

- Promoting the use of clean energy technologies, efficiency and conservation
- Maintenance or renewing an ecologically strong environment
- Expansion of electrical generation from renewable or alternative fuels.
- Use of biomass including landfill methane
- Development of bio-fuels including ethanol and bio-diesel
- Providing the lowest possible cost energy consistent with other goals
- Increased economic development through the creation and expansion of alternate energy manufacturing and distribution
- Reduced reliance on imported sources of energy

Specific Policies used in various ARC states include:

- **Net Metering** where those who use certain qualified distributed generators using renewable or alternate fuels receive credit or payment for the electricity they produce. Either by using a single meter which “runs backward” as the customer generates their own electricity or by use of two meters where the customer’s generation is directly metered to the grid by one meter while another measures the total electricity used by the customer, the customer receives either credit on their bill or payment for the electricity they create.

Net metering is allowed in Virginia, Maryland, Ohio, Kentucky, New York and in Georgia among the ARC states. It is also available through the Tennessee Valley Authority in the parts of Tennessee, Mississippi and North Carolina served by the TVA. The provisions in these laws vary including what types of renewables are eligible, what size generators can be used, whether the programs are voluntary or compulsory, what price is to be paid for the distributed generation, who pays for the installation to the grid and the total amount of generation a utility must accept.

- **Renewable Energy Portfolio Standards** require that a certain percentage of the power either generated or consumed in a state must come from renewable fuels. The utility is required to either build a renewable facility or buy renewable energy from another generator to meet the requirement. New York, Pennsylvania and Maryland have these in the ARC region.

  There is not agreement among the states as to what should be considered as "renewable energy". All include solar and wind along with small scale hydro. Landfill gas appears in most cases. In Pennsylvania the standard includes waste from wood or coal as well as demand side management. Often these standards are divided into tiers with requirements that given percentages must be met by using certain fuels such as solar or wind. While these tiers add complexity to the standards they are considered desirable to encourage the development of certain renewables.

  A recent development is the market for Renewable Energy Credits. Under this program a generator using renewables can meter the amount of energy produced. It then sells this renewable energy in one mega watt credits which can be purchased by a utility to meet its renewable requirement.

- **Public Benefit Funds** which attach a small charge to each customer's monthly energy bill are used in New York, Ohio and Pennsylvania. Monies collected under these programs are used in a wide variety of ways.
  - Subsidize energy consumption by low income households
  - Provide weatherization programs
  - Make low cost loans or grants for installation of renewable or alternate generation
  - Support research and development of renewable, alternate and efficient energy
  - Encourage location of renewable energy related industry in the state
  - Remediation of impacts from pollution caused by generation from conventional fuels

- **Grant and Loan Programs** are available in all ARC states for certain uses. These encourage the adoption, installation and use of alternate or renewable technologies, provide low cost loans, promote energy efficiency education, assist low income consumers, finance research and development, locate renewable energy manufacturing, support use of biofuels and reward energy conservation. Differences in state programs are considerable. Those differences reflect both the priorities and financial capabilities of the states using them.

- **Tax Incentives** are not as widespread as other inducements, but some individual states in the ARC area grant personal and corporate tax incentives such as deductions or credits for installing or producing renewable or alternate energy. These incentives in some cases are used to attract producers or distributors of alternate energy to a state. Favorable sales tax and property tax treatment is even less available. New York, Maryland, North Carolina, Tennessee, Virginia and West Virginia among the ARC states provide or allow property tax exemptions or rate reductions for certain forms of renewable generation or installation. Limited sales tax reductions are also available in Georgia, New York, Maryland and Ohio for renewable installation.

- **Rebate Programs** serve the same purposes as other incentives. New York, Maryland, Pennsylvania, South Carolina and Kentucky have targeted rebate programs. Most of these concern installation of solar equipment with some extension for other types of energy efficient appliances.

- **The Green Power Partners Program** is offered in the TVA territory. Green power from renewables is sold in 150 kWh blocks at $4 per block. The Green Power is generated from TVA's wind, solar and methane plants. The program allows consumers to support the generation of clean energy by a slight additional charge. North Carolina has a similar program.

Hydrogen R & D

Within the ARC region hydrogen research has focused on all major categories on current research including production, use, delivery and storage. While there is production from natural gas taking place in industrial settings to be transformed into other products, production is costly and it is not practical to use it other than as a feedstock. Storage problems have not been resolved with further reduces its use as a fuel.

Production of hydrogen from renewable energy will most likely result from renewable electricity. Currently, this is not cost effective given the state of technology. Hydrogen is likely to achieve the highest potential efficiency by use in fuel cells when the problems of durability and efficiency for that technology are resolved.

Oak Ridge National Laboratory in Tennessee is the center for hydrogen research in the ARC. There are currently at least 15 hydrogen research projects underway in the area with significant work being conducted at Pennsylvania State University, Virginia Polytechnic, Ohio University, University of Pittsburg and the University of Alabama.

Corporate Energy Efficiency and Renewable Energy

There are many examples within the ARC of firms and government entities which have profited from energy efficiency programs or the use of renewable energy.

- The **Volvo New River Valley** plant in Dublin, Virginia has reduced its use of energy and water. Recycling has cut landfill waste in half and energy use per truck produced has dropped by more than 60 percent.
- The **Radford Army Ammunition Plant** in Radford, Virginia saw energy used reduced by 230 billion btu per year due its low cost energy conservation initiatives.
- **Statton Furniture** in Hagerstown, Maryland uses wood waste as a fuel source for its operation resulting in a 60 percent yield on lumber.
- **Steel of West Virginia** in Huntington is a highly intensive user of energy. Due to its energy saving alterations it saves over $1.6 million each year.
- **BMW Manufacturing** in Spartanburg, South Carolina manufactures some of the nation’s most appealing vehicles. It receives 53 percent of its energy needs from methane in a nearby landfill
- **Heil Environmental** in Tishimingo, Mississippi manufactures refuse truck bodies. Following an energy assessment and implementation of the findings significant savings resulted. These savings led to the decision not to close the plant and maintain the 200 jobs.
- **AK Steel Works** in Russell, Kentucky produces carbon and low carbon steel. Due to the installation of energy efficient processes and recycling it now reclaims up to 250,000 tons per year and has reduced its per ton use of energy by 3 percent.
- **Commonwealth Aluminum/Aleris Rolled Products** in Uhrichsville, Ohio produces aluminum alloys. Energy efficiency upgrades save the company over $1 million per year.
- **Ragland Clay Company** in Ragland, Alabama manufactures brick and brick pavers. It uses a biomass gasification unit which employs wood chips as fuel. This saves between $400 and $600 a day in energy costs.
- **Hazelton St. Joseph Medical Center** in Freeland, Pennsylvania is heated and cooled with a geothermal air conditioning system resulting in significant energy savings.
- **Kopernik Space Education Center** in Vestal, New York installed a geothermal HVAC system eliminating the need for natural gas. The project has a payback period of about six years.
- **EnergyXchange Renewable Energy Center** in Burnsville, North Carolina uses landfill gas to a fuel pottery kiln and glass furnace at its center.
- **Rohm and Haas Company** in Knoxville, Tennessee produces various chemical products. Following an energy assessment, electricity use was reduced resulting in a $1.5 million savings.

- **US Biofuels** in Rome, Georgia makes biodiesel from poultry grease. It is expanding its production from 300,000 to 800,00 gallons a month.

These are a few of the many ways that energy efficiency and the use of renewables are contributing to the growth of business and increased competitiveness of the ARC counties.

Energy Intensity in Appalachia

It is important to understand the pattern of energy use as a means to evaluate policy interventions. While state wide data is available it is difficult to find appropriate county level data for the ARC counties. The report provides estimates of per capita energy use as a function of personal income, average annual temperature spreads, manufacturing's share of employment income and proportion of a county in an urban area.

For the ARC states as a whole, eight have above average energy use per capita with the southern states having the highest intensity due to their relative sparse populations and low energy costs. County specific results showed broad dispersion in per capita energy use with manufacturing and population density having the most important influences. In many instances results showed above average use due to the heavy concentration of manufacturing compared to population. A sparsely populated county with even a moderate level of manufacturing can have a high intensity.

When energy consumption per unit of personal income is used as a measure there were again significant variations. Economically distressed counties with low incomes and little manufacturing ranked low by this measure. The presence of a single manufacturing plant in one of these counties significantly changes the result.

In the short run neither business nor residential consumers are very sensitive to changes in energy prices. This is not surprising and is consistent with the bulk of research completed elsewhere. For the ARC counties the price elasticities for residential users and commercial users were -0.15 and -0.17 respectively with industrial users having a coefficient of -0.55. While still not responsive to short run changes in prices, industrial users with their higher energy demands are more sensitive than others. The conclusion is that efforts to improve energy efficiency in the short run will require subsidization to encourage adoption.

Conclusions

This overview of the renewable and alternative energy potential of the ARC region lead to some preliminary conclusions and recommendations. As study continues these are subject to alteration or rejection. Others may be added.

ARC State Differentials

The differences between and among the ARC states are substantial. These reflect one or more of the following:

- Political Philosophies. States in the upper part of the ARC region are more receptive and supportive of government programs. The Southern states are less accommodating. This is particularly true for policies and regulations which are viewed as requirements or even dictates. This has led to generally less government involvement in the Southern states in most areas including energy. For example, no Southern state has a RPS in place.
- Demographic Differences. While the counties in the states in the ARC all share the mountains, there are substantial demographic differences between and among them. Table E.1 provides a summary. Data for the ARC counties is given in Appendix C which shows even greater variations among the ARC region. All the states except New York and Maryland have per-capita incomes below the national average. The southern tier with the exception of North Carolina are all well below. Maryland, Pennsylvania and Virginia are the only states with poverty levels below the national average. Population density varies considerable with only Mississippi and West Virginia falling below the national average.

Table E.1: ARC States Statistics

	Per capita income in 1999 (dollars)	% in Poverty	Total Population	Population Density per sq. mile	Median Age	Taxes per-capita
United States	**21,587**	**12.4%**	**281,421,906**	**79.6**	**35.3**	**2,014.36**
Alabama	18,189	16.1%	4,447,100	87.6	35.8	1,550.99
Georgia	21,154	13.0%	8,186,453	141.4	33.4	1,633.84
Kentucky	18,093	15.8%	4,041,769	101.7	35.9	2,043.31
Maryland	25,614	8.5%	5,296,486	541.9	36	2,216.86
Mississippi	15,853	19.9%	2,844,658	60.6	33.8	1,766.54
New York	23,389	14.6%	18,976,457	401.9	35.9	2,376.77
North Carolina	20,307	12.3%	8,049,313	165.2	35.3	1,971.48
Ohio	21,003	10.6%	11,353,140	277.3	36.2	1,962.93
Pennsylvania	20,880	11.0%	12,281,054	274.0	38	2,045.09
South Carolina	18,795	14.1%	4,012,012	133.2	35.4	1,620.67
Tennessee	19,393	13.5%	5,689,283	138.0	35.9	1,617.03
Virginia	23,975	9.6%	7,078,515	178.8	35.7	1,902.56
West Virginia	16,477	17.9%	1,808,344	75.1	38.9	2,067.85

Source: U.S. Census Bureau: 2000 Census of Population and Housing

- Tax Effort. The low incomes and high poverty rates restrict the financial ability of many ARC states to subsidize the use of renewables and energy efficiency. While it is to be expected that the higher income states (New York, Maryland, Pennsylvania and Virginia) would have per capita taxes above the national average, low income states Kentucky and West Virginia do also. The states with the greatest financial capacity have the most fully developed alternate energy and energy conservation programs.

- Influence of traditional providers. In those states with few providers using traditional fuels there appears be less urgency attached to increased renewable or alternate energy. States where coal is a significant industry may view these newer sources as competition which has the potential to undermine the recent prosperity which coal has created. In the absence of a regulatory push been slow to adopt policies which encourage renewable or alternate fuels in electric generation. This is particularly true in states with surplus generation capacity and strong export markets to other states.
- Cost Differentials. There are significant differentials in the average cost of electricity among the ARC states. Using 2004 FERC data New York at 12.55 cents per KWh is 270 percent of Kentucky's 4.83. For the ARC region as a whole the average cost is 6.43 compared to the national average of 7.62. The further north one goes in the ARC region the higher the electricity costs. The lower costs in the southern states make it more difficult to justify on economic grounds use of alternative fuels or implement energy efficiency programs.
- Level of Electric Deregulation. The higher electric energy cost northern ARC states have been the most active in embracing retail electric deregulation in the hopes of reducing costs to consumers. Only New York, Pennsylvania Maryland and Ohio have deregulated either in whole or in part. Those states are also the most active in promoting energy efficiency programs. There have been no states in the U.S. which have deregulated since 2000 and there is little interest in the ARC states of going further.
- Energy Endowments. As this report shows, all the ARC states have considerable alternative and renewable energy resources. The cost competitiveness of these sources with traditional coal generation creates a barrier in coal rich states. The relative high up-front costs of alternate energy presents a barrier in the deregulated states as those costs can not be rolled into the rate base as is the case in states with traditional regulation. In addition the sources of renewable energy vary widely with wind showing the greatest potential in the states with attractive ridge lines and biomass in the states with significant agricultural activity. This diversity of endowments means that a single path will not be followed by any of the ARC states nor should it be encouraged.
- Interest in Biofuels. To varying degrees all the ARC states have strong interest in the development of biofuels: biodiesel and ethanol. The current and forecast high prices for gasoline have made these alternatives competitive. In addition, the desire to replace imported oil has become an additional motivation. States also recognize the economic development potential of development of biofuels. Locating biofuel production will create jobs and increase income in those states where the manufacture of biofuels is located. State policies range from subsidies, tax breaks, loans and guaranteed purchase arrangements. Each state will capitalize on the bio-fuel which is most abundant in their region.

Methodology

This report was compiled using information gathered from a variety of sources. Published works generated by public bodies, research organizations and industry groups were reviewed. These are listed in the "References" to the report. The profiles provided in the DSIRE file were also consulted and updated. The primary source of information was in-depth interviews conducted with state officials in all ARC states and the TVA. They provided current information and examples of the work ongoing in their jurisdictions. These contacts are provided in Appendix A to the report.

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Overview

This report surveys potential and underutilized sources of renewable energy available within the Appalachian region, focusing on the physical availability of these resources and the policies in place to support them. Like much of the U.S. this region possesses considerable amounts of unused renewable energy resources, with wind and biomass among those that appear most promising in the near term.

As a frame of reference, current regional power generation in megawatt hours (MWh) for the counties in the ARC region is shown in Table 1.1 below. These figures only describe the portion of each state's generation that is from plants physically located in the 410 ARC counties. Because West Virginia lies entirely within the Appalachian region, 100 percent of its generation is shown. When excluding hydropower the existing generation mix contains less than one percent renewable sources. Overall, like the U.S. as a whole the region's generation mix is characterized by large nuclear and coal-fired plants that supply base load electricity demand.

Table O.1: Electricity Generation by Energy Type in ARC Counties (MWh)[1]

Sum of Net Generation by Energy Type in ARC Counties (Megawatt hours)										
Energy Source	**Coal**	**Oil**	**Natural Gas**	**Nuclear**	**Landfill Gas**	**Wind**	**Water[2]**	**Others**	**Total in ARC**	**% of State Total**
AL	56,148,521	105,593	1,478,459	18,487,804			9,332,246	825,542	**86,378,165**	**62.9%**
GA	37,244,697	43,758	4,761,857		17,601		1,578,203	224,139	**43,870,254**	**34.6%**
KY	10,009,562	22,300	147,783		32,330		1,448,728		**11,660,703**	**12.3%**
MD	2,147,691	6,490					33,504	162,987	**2,350,672**	**4.5%**
MS	3,202,897	5,478	3,519,471					626,588	**7,354,433**	**16.8%**
NC	17,132,089	54,003	127,124		28,946		3,130,738	170,960	**20,643,861**	**16.3%**
NY	6,557,253	18,875	353,794				-431,297		**6,498,625**	**4.7%**
OH	104,601,172	236,851	924,400				428,959	409,249	**106,600,631**	**72.0%**
PA	98,487,537	337,655	1,912,084	32,016,480	103,502	306,312	525,375	853,841	**134,542,786**	**62.7%**
SC	1,123,081	37,766	2,415,278	18,667,495			-621,303		**21,622,316**	**22.1%**
TN	20,483,082	51,765	21,386	28,612,271	12,033	3,813	6,773,159	264,508	**56,222,017**	**57.6%**
VA	5,431,820	16,148	38,199				-643,914		**4,842,254**	**6.1%**
WV	87,588,841	267,615	252,768			161,191	1,590,298	160,867	**90,021,580**	**100.0%**
Total in ARC	**450,158,243**	**1,204,298**	**15,952,603**	**97,784,050**	**194,411**	**471,316**	**23,144,695**	**3,698,682**	**592,608,297**	**41.0%**
% of ARC	**76.0%**	**0.2%**	**2.7%**	**16.5%**	**0.03%**	**0.1%**	**3.9%**	**0.6%**	**100.0%**	

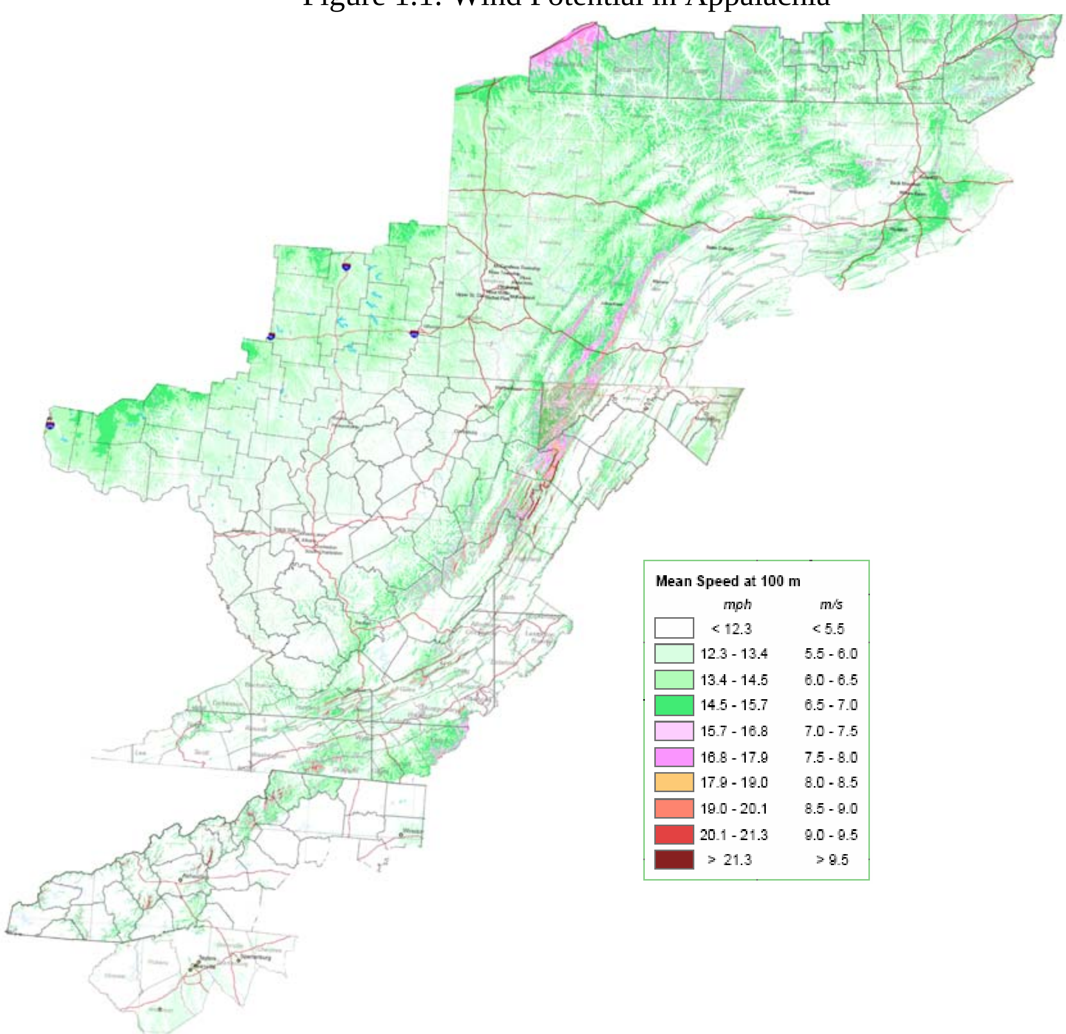
[1] U.S. Department of Energy, Energy Information Administration (2005). EIA-860 Database Annual Electric Generator Report and Electric Power Monthly.
[2] A negative number represents use of pumped storage for peak power generation which is a net consumer of energy for the storage process.

Chapter I. Resource Availability

1. Wind

The harnessing of wind power to produce electricity is significantly underdeveloped 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[3]



[3] TrueWind Solutions, LLC

State by state estimates of wind potential have been calculated by various sources and are thus varied. Table 1.1 shows estimated wind capability for the states in the ARC area with the most wind potential. Other states have either not conducted detailed estimates or have not made those estimates available. 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 based only on about 30 percent of installed capacity.

Table 1.1: Potential and Installed Wind Capacity by ARC State

State	Installed MW	Proposed MW	Potential (MW)	Area of Potential
New York	280	235	5,000+	On land
Pennsylvania	153	210	5,120	State wide
Maryland	0	181	338	State wide
West Virginia	66	300	3,830	On private land
Virginia	0	39	1,380	On land
North Carolina	0	0	835	State wide
Tennessee	29	0	186	State wide

Sources: American Wind Energy Association and TrueWind Solutions, LLC

The installed numbers listed above do not include residential installations.

2. Solar

The ability to fully utilize solar energy remains restricted by technology and cost. The Appalachian region has moderate to low solar capability, relative to the rest of the country, 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.

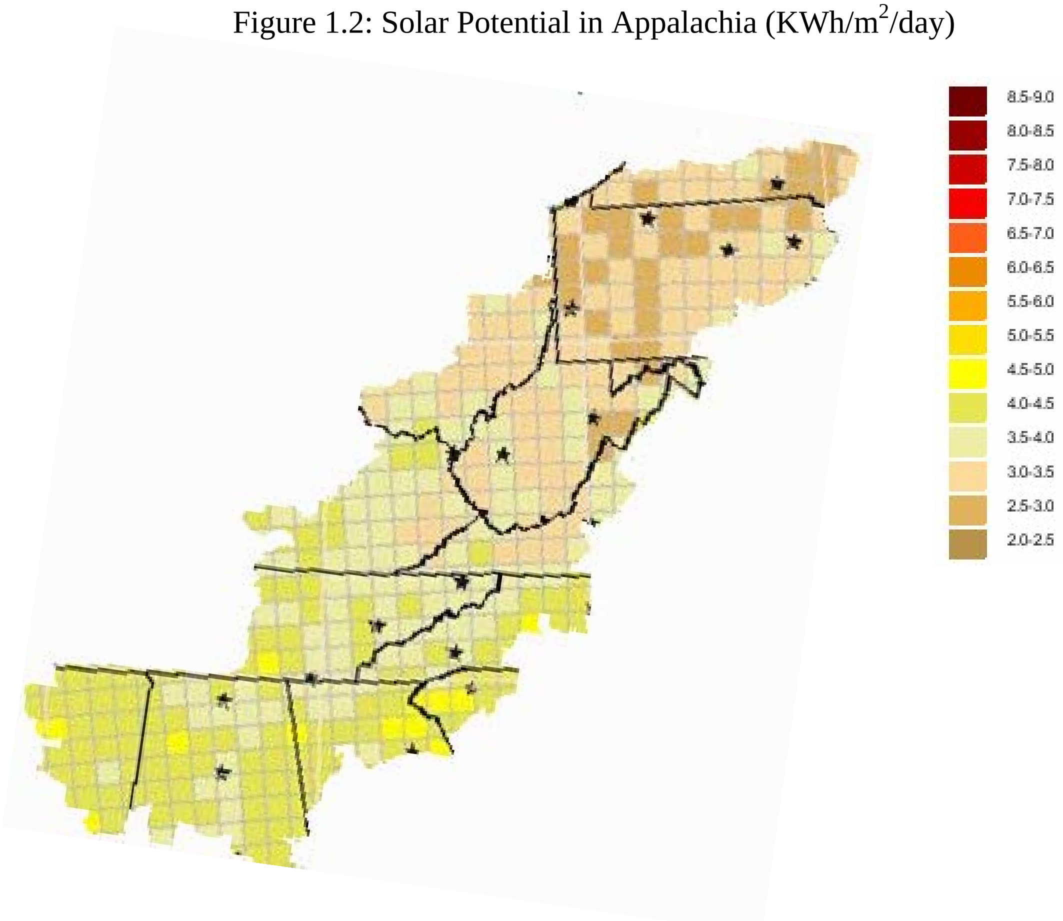
Solar power's best potential in the eastern U.S., including Appalachia, is likely to be for residential or commercial application, and subsidies are currently necessary to induce adoption. Passive solar installations such as daylighting, transpired heat collectors (solar ventilation air preheating), hot water heaters and pool heating may give the best return on current investment in solar technology.[4]

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 4,200 KWh per year represented by a brown grid in Maryland or Pennsylvania, and 6,900 KWh represented by a yellow grid in Georgia, depending on if the PV panels were fixed tilt or had two-axis tracking.

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

In relation to daily electricity consumption, this resource can meet a portion of the average household demand in the ARC region. Average demand ranges from about 5,500 KWh per year in less electrified states such as New York (15 KWh per day) to nearly 12,900 KWh per year (35 KWh per day) in highly electrified states such as Tennessee. In Georgia and South Carolina, where potential is best, this resource 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, which could improve these ratios for all areas. Doubling system size to 6 MW would cover demand for most households.

Figure 1.2: Solar Potential in Appalachia (KWh/m^2/day)



There are currently no utility-scale solar power installations in the Appalachian states. However, an unknown number of residential and commercial installations do exist within the area. Notable projects include the multiple school projects in place in West Virginia, Kentucky, Pennsylvania, Virginia and Ohio in partnership with American Electric Power's "Learning From Light" program.[5]

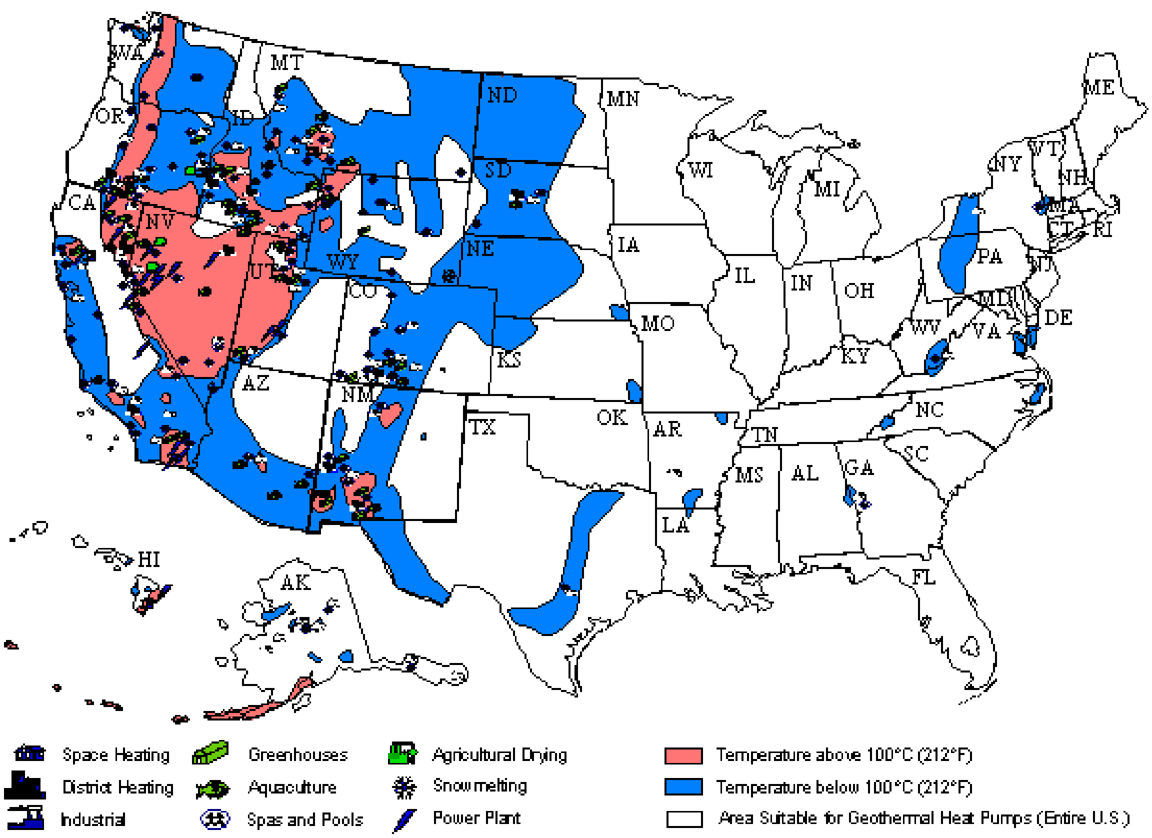
[5] http://www.aep.com/environmental/education/solar/

3. Geothermal

Within the Appalachian region there is very little variation in geothermal capability. As shown in Figure 1.3 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 or the eastern U.S. 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.

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 air or water – generally between 55 and 70 degrees Fahrenheit - and heated, then further heated via a heat pump as necessary and returned as warm air. 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. 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.[6] There are already several geothermal systems installed in the ARC region. These systems are most cost-effective for residential and small commercial buildings.

Figure 1.3: U.S. Geothermal Projects and Resource Areas[7]



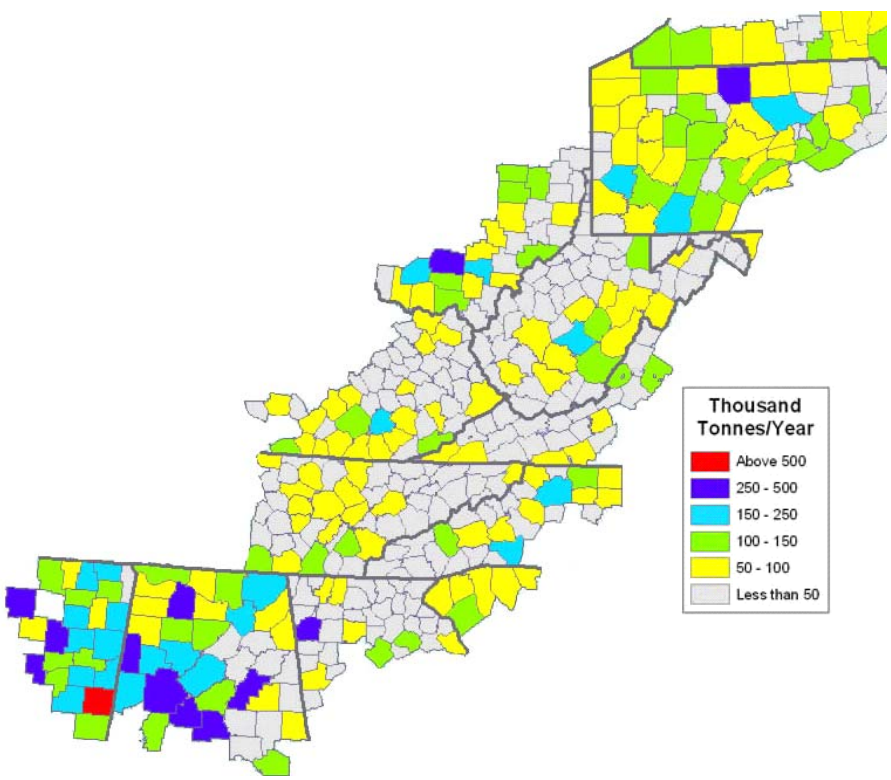
[7] Geo-Heat Center.

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 (e.g. sawn lumber, pruned branches, trees, stumps, pallets, demolition waste) and dedicated energy crops grown on Conservation Reserve Program (CRP) and Abandoned Mine Lands property. Figure 1.3 shows estimates of 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 and 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 1.4: Biomass Potential in Appalachian Counties[8]



[8] National Renewable Energy Laboratory, 2005.

Table 1.2: Biomass Resources Available by State (thousand tonnes/year)[9]

State	Crop Residues	Switchgrass on CRP Lands	Forest Residues	Methane from Landfills	Methane from Manure Management	Primary Mill	Secondary Mill	Urban Wood	Methane from Domestic Wastewater	Total Biomass
Alabama	391	2,660	2,555	236	94	5,857	57	483	7	12,340
Georgia	997	1,646	3,556	201	139	7,231	97	924	14	14,804
Kentucky	1,722	1,822	2,055	250	34	1,433	52	454	7	7,830
Maryland	584	271	263	204	6	138	33	624	9	2,131
Mississippi	2,191	4,883	3,825	93	72	4,548	33	307	5	15,956
New York	507	264	1,111	885	10	1,063	119	2,041	31	6,031
North Carolina	1,494	577	2,995	427	370	3,900	115	833	13	10,726
Ohio	5,001	1,587	796	647	41	786	124	1,272	19	10,272
Pennsylvania	810	672	1,679	642	23	1,358	127	1,238	20	6,569
South Carolina	331	1,061	1,733	181	30	2,468	38	467	7	6,315
Tennessee	1,501	1,375	1,319	274	20	1,557	75	614	9	6,745
Virginia	502	297	2,403	275	23	2,147	62	813	12	6,535
West Virginia	32	9	1,347	47	1	807	15	184	3	2,445

Crop Residues – Includes corn, wheat, barley, soybeans, cotton, sorghum, oats, rice, rye, canola, beans, peas, peanuts, potatoes, safflower, sunflower, sugarcane and flaxseed. It is assumed that about 35 percent of crop yield is available to be collected as biomass.

Switchgrass –The CRP is a voluntary program through the USDA that promotes growth of hearty crops such as switchgrass on land not suited for conventional farming.

Forest Residues – Includes logging residues, pre-commercial thinning and clearings not associated with round wood products harvests,

Methane from Landfills – Based on the EPA's Landfill Methane Outreach Program

Methane from Manure Management – Includes methane produced from liquid manure management systems that collect waste from dairy cows, beef cows, hogs and pigs, sheep, chickens (layers and broilers) and turkey.

Primary Mills – Course and fine byproducts of mills that produce primary wood products (slabs, edgings, trimmings, sawdust, veneer clippings, pulp screenings).

Secondary Mills – Wood scraps and sawdust from woodworking shops.

Urban Wood – Municipal solid waste, tree trimming, and construction demolition waste.

Methane from Domestic Wastewater - Based on the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks

[9] U.S. Department of Energy, National Renewable Energy Laboratory (2005). "A Geographic Perspective on the Current Biomass Resource Availability in the United States."

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. This category of hydroelectric generation is based on damless technology. Opportunities to develop new and pre-existing dams for hydroelectric power are certainly available in the region, and are being pursued, but are not evaluated here. All of the more than 30,000 MW of installed utility-scale hydroelectric power that exists in ARC states is based on dammed resources, including pumped storage.[10] Types of this resource, in terms of small and low power resources as defined by the Idaho National Laboratory, are[11]:

- Small hydro: < 30 megawatts and hydraulic head > 30 ft.
- Low head/low power hydro:
    - Conventional Turbine: >= 100 KW and < 1 MW and hydraulic head >= 8 ft but < 30 ft
    - Unconventional Systems: >= 100 KW and < 1 MW and hydraulic head less than 8 ft
    - Microhydro - power less than 100 KW (typically for residential use)

Hydraulic head is a defining characteristic of hydro systems. It is essentially water pressure, which is created by the difference in elevation between the water intake and the generating turbine. Higher head generally means more efficient power generation Installations of any of these sizes could be termed "run of river" systems because they do not require a dam. These systems do require earthen diversion channels and possibly filtration ponds to remove sediment from the water prior to running it through a pipeline, or penstock, to the area where the turbine is housed.

Small hydro systems would most likely utilize a conventional Pelton turbine which looks much like a metal waterwheel with small buckets that turns when struck with water. Low head systems would most likely utilize a "cross-flow" turbine, a type of impulse turbine that utilizes the force of sheets of water and blades that rotate around a hollow center where the water flows. A cross-flow turbine could be used in conventional or unconventional system due to its ability to take advantage of low hydraulic heads. Another example of an unconventional system is hydrokinetic technology, variations of which are similar to a submerged wind farm. Microhydro systems are generally designed to charge battery-powered electric systems which are the primary source of electricity for a building instead of providing electricity for immediate use.

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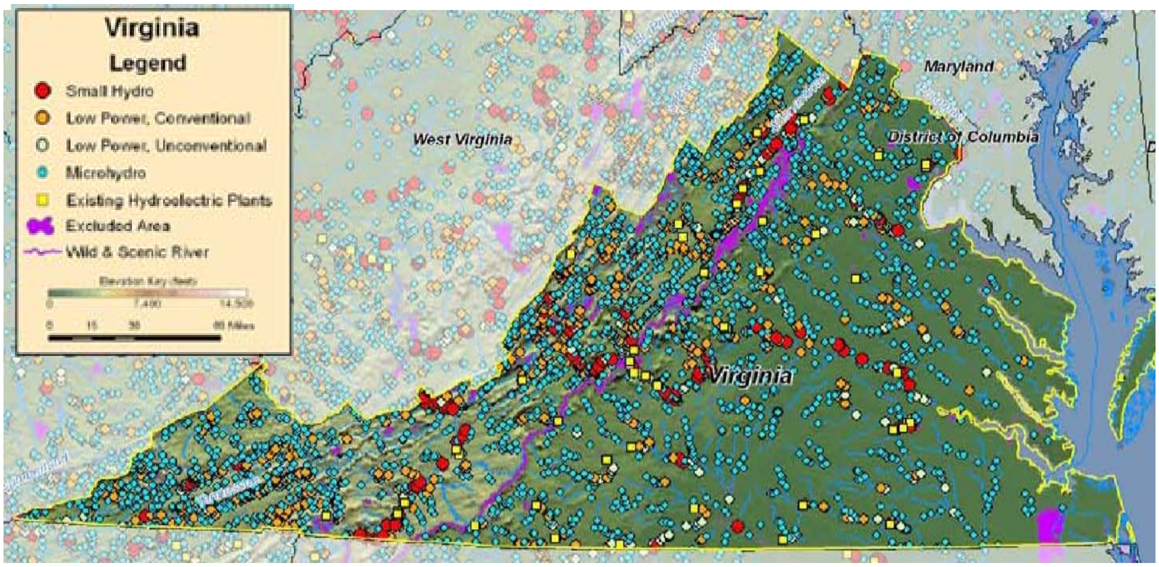
[10] Energy Information Administration, 2005. Annual Electric Power Industry Database (Form EIA-860) from http://www.eia.doe.gov/cneaf/electricity/epa/epat2p2.html

[11] Idaho National Laboratory, April 2004. "Water Energy Resources of the United States with Emphasis on Low Head/ Low Power Resources."

The Idaho National Laboratory has estimated feasible hydropower potential for each state for each category of small and low power hydro. A sample for the State of Virginia with potential installations is shown in Figure 1.4 below.

Figure 1.5: Small Hydropower Potential in Virginia[12]



Feasibility is based on existing land use designations. The above estimates do not include streams excluded from development by federal statutes (national parks and monuments, wilderness 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. Included areas correspond with those designated as GAP Code 3 or 4 as defined by the Conservation Biology Institute. These areas include national forests, wildlife management areas and Bureau of Land Management lands. Additional maps for all 13 ARC states are included in Appendix A.

Hydro installations of these types are uncommon in the eastern U.S. and only one example could be found within the Appalachian region. Appalachian State University hosts a series of renewable energy workshops that include a small hydro installation demonstration.[13] Examples in the western U.S. include Canyon Hydro, a manufacturer of hydroelectric system parts in Washington State, municipalities and schools such as Utah State University as well as residential systems up to 30 KW in size. Examples of grid-connected systems as small as 250 KW were found.[14]

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[12] 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."
[13] Appalachian State University, July 25, 2006. http://www.wind.appstate.edu/workshops/workshops.php
[14] Canyon Hydro, July 25, 2006. http://www.canyonhydro.com/Projects/ProjectsCom/ProjectsCom.htm

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 1.3: Estimated Feasible Small and Low Power Hydropower by ARC State[15]

			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. Because of the small scale of many of these projects, it is likely that these facilities would be used to power individual residences, small communities, commercial buildings or schools. Proximity to a water source is likely to be the determining factor. Any of these projects may have excess power that could be sold to the grid, provided that direct purchase or net metering arrangements were in place and appropriate permits were obtained from the Federal Energy Regulatory Commission.

There may be some limitation placed on the expanded use of low impact and low flow hydro by state water law. Riparian rights refer to those whose property abut or cross a stream not to have their use of that water "unreasonably" reduced either in quality or quantity. In all cases where the law involves determinations of "reasonableness" the judgment is based on individual circumstances. Among the benefits claimed for low impact and low flow hydro is that there is no diminution of either the quantity or quality of the water used as it is all returned to the stream in original volume and purity. Still, this is an area which each ARC state should consider its own water law as it develops a policy on hydro.

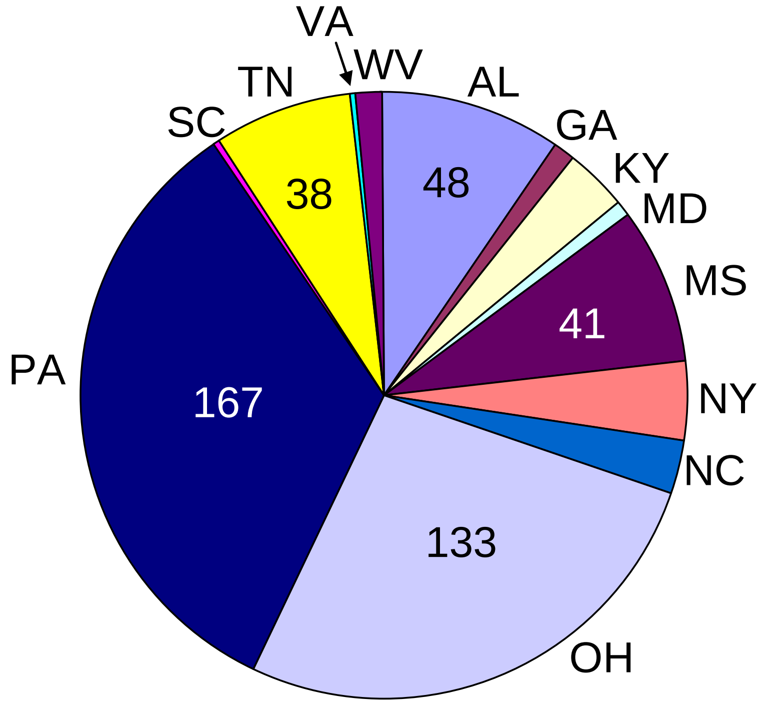
[15] Ibid.

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, a native prairie tallgrass, rapeseed oil, canola oil 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 (MTBE) due to the Federal requirement to phase-out MTBE.

The following figure shows calculated potential biodiesel production from soybeans and ethanol from corn based on total 2005 production of those crops in ARC counties. Total potential production is approximately 500 million gallons per year, or 12 million barrels of oil 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 1.6: Potential Annual Biofuels Production by State (millions of gallons)[16]



[16] U.S. Department of Agriculture, 2005 Census of Agriculture. National Agricultural Statistics Services.

An alternative biofuel which is receiving increased attention in the southern ARC states is switchgrass[17]. Switchgrass being native to the region is highly productive (two to three 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[18].

Widespread use of biofuels can not occur without access to fueling stations. A potential partner is Wal-Mart, the first major retailer to announce an interest in installing E-85 dispensers at all its stores.[19] Appendix B of this report discusses this possibility in more detail.

7. Chicken Litter

Chicken litter is technically a type of biomass and is included in the assessment described above in section four in the category "methane from manure management." The 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 (meat chicken) manufacturing in the Appalachian region would produce little electricity on its own. The combined litter of the approximately 327 million broilers produced annually 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.[20] Cow manure also contains recoverable methane and is also used in digester projects, including one at the University of Georgia which borders the Appalachian region.

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.

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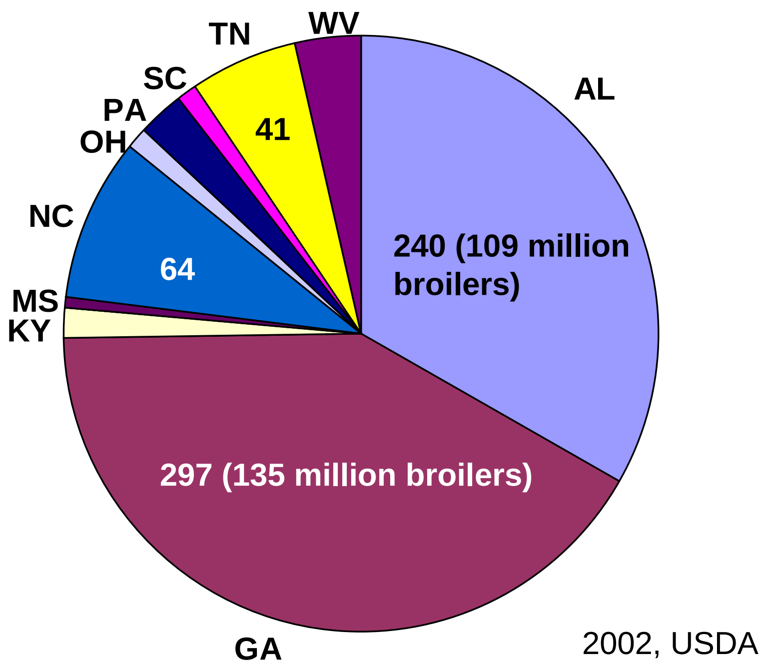
[17] "Biofuels from Switchgrass: Greener Energy Pastures" Oakridge National Laboratory http://bioenergy.ornl.gov/papers/misc/switgrass.html

[18] Bransby, D. "Switchgrass Profile" Oakridge National Laboratory http//bioenergy.ornl/papers/misc/switchgrass-profile.html

[19] June 1, 2006, Associated Press. "Wal-Mart May Start Pumping Ethanol: Retail Giant Owns And Operates 383 Gas Stations In U.S."

[20] http://bioplexproject.wvstateu.edu/index.html

Figure 1.7: Potential Annual Electricity Production From Broiler Litter (MWh)[21]



Including layer (egg chicken) production as well would increase these figures.

[21] U.S. Department of Agriculture, 2002 Census of Agriculture. National Agricultural Statistics Services.

Chapter II. State Policies Promoting Use of Renewable Energy, Alternate Energy and Energy Efficiency in the ARC Region

There are a variety of policy measure adopted by the ARC states to promote the use of renewable energy, alternate energy, energy efficiency and conservation. This section provides an overview of these policies with highlights of developments in particular ARC states. In addition the activities of the Tennessee Valley Authority (TVA) are also covered as its programs cover all of Tennessee and impact significant portions of other states in the ARC region.

Recent years have seen the passage or proposal of comprehensive energy plans in many ARC states. Many of the specific provisions in those plans are detailed later in this chapter.

- In 2002 **New York** enacted *2002 State Energy Plan and Final Environmental Impact Statement (Energy Plan)* which provides for increased energy diversity through use of energy efficient technologies and alternative and renewable energy.
- **Georgia** has issued a draft *State Energy Strategy for Georgia* which is due for final release in September 2006. The draft plan stresses the production of ethanol and biodiesel and programs to increase the production of renewable energy.
- **Kentucky**'s Governor has presented *Kentucky's Energy Opportunities for Our Future: A Comprehensive Energy Strategy (2006)* for consideration by the legislature. One of the plans objectives is to maintain the low cost of energy in the state. It also emphasizes biofuels production and a promotion, but not mandate, the use of renewable resources in the sates electricity generation portfolio.
- The *North Carolina State Energy Plan (2005 revised)* sees biomass (including animal waste) resources as having the greatest potential among renewable fuels in **North Carolina.** It also calls for consideration of a Renewable Portfolio Standard to encourage alternate energy development.
- The 2006 **Virginia** legislature passed *The Commonwealth Energy Policy*. The policy places heavy emphasis on research. Clean coal, wind and solar are specifically mentioned for further development as is the increased use and production of biofuels.
- **West Virginia** passed the *West Virginia Energy Policy and Development Act* in the 2006 session establishing a Division of Energy within the Department of Commerce and continuing the Public Energy Authority. The division was charged with energy policy and economic development in coalfield communities. The Authority is to prepare an annual plan for energy diversification and efficiency.
- **Pennsylvania** has under consideration *The Pennsylvania Energy Development Plan* (April 2006 Draft). It focuses on programs to increase energy security, promote environmentally friendly energy resources, encourage economic

development through energy related industries, support technology development and promote energy conversation. The plan is under consideration by the Pennsylvania Development Authority.

1. Net Metering

Net metering allows customers with qualified renewable or alternative energy generators to receive credit or payment from the utilities for the electricity they generate. Under these programs residences and businesses generating electricity using renewables such as solar, small scale hydro, wind or geothermal are able to participate. This is usually accomplished by a single meter which “runs both ways”. When electricity is being taken from the utility the meter runs forward and when electricity is being supplied by the customer it runs backward reducing the “net” amount to be billed.

In other states there is a dual meter system. The energy taken from the grid is metered as it is used while a second meter records the energy which is returned to the grid from the use of renewables. The customer is charged for all energy taken and receives a credit on the next month’s bill for energy supplied.

A major issue regarding net metering is the price to be paid for the electricity generated. When a single meter is used this is not an issue as the only bill received by the customer is what is supplied by the utility. When a dual meter system is employed the issue becomes will the generator receive credit or be paid at the retail tariff he is being charged or some other rate. In some states the price is set at the utility’s “avoided cost” which is the lowest cost of power obtained from its own generation or purchased from another utility. Experience is some states with avoided cost has meant the return on installing small generation facilities can not be capitalized in a reasonable time period if at all.

There is an issue with safety and reliability. All net metering states require that the renewable installation meet certain standards such as those of Underwriters Laboratories, National Electrical Code or the Institute of Electrical and Electronics Engineers. While no state requires its utilities to pay for the renewable generator or its installation, there is variance as to who must pay for the cost of interconnection.

TVA and its related utilities have established net-metering for all residential and commercial customers through their Green Power Switch Program in **Tennessee, Georgia, Mississippi** and **North Carolina.** In addition TVA has a pilot Generation Partners Program. A two meter system is used with the TVA purchasing all the output at $0.15 for residential customers. For larger customers with units up to 50 kW the rate is $0.20. Larger units may be included with permission from TVA. For residential and small commercial both solar and wind systems are included, but larger commercial enterprises are limited to solar. For the ARC states only 22 of their distributors are involved and only 20 residential customers are currently connected. Of the 158 distribution companies supplied by TVA, 98 offer the voluntary program.

In **Virginia** the program is limited to residential systems with less than 10 KW capacities while the limit on commercial systems is 500 KW. Their program extends not only to renewables but to biomass, waste and sea motion. They use a single meter measuring flows in both directions.

Maryland's legislation allows net metering for systems with capacities up to 200 KW without Public Service Commission approval and up to 500 KW with approval. Solar wind and biomass systems are covered. A single bi-directional meter is used. The Maryland program is under revision to develop a credit system (other than based on capacity) which allows dollar for dollar offsets for electricity generated. There is a limit on allowable capacity equal to 0.2 percent of the state's peak load forecast.

The **Ohio** situation is similar to that in southern ARC states. All fuels including micro turbines and fuel cells are included. For power furnished to the grid the utility must pay their unbundled generation rate. New rules are under consideration by the Public Utilities Commission of Ohio (PUCO)
.
Net metering is provided in **Kentucky** for both private and co-op utilities only for solar units of 15 kW or less. But the states two largest utilities, Kentucky Power and Louisville Gas and Electric, extend the program to wind and hydro generation. A single bi-directional meter is used. There is a limit of 0.1 percent of the utilities' single-hour peak load that can be net-metered.

Net Metering rules in **New York** allow customers to sell the net excess generation from photovoltaic systems with a capacity of up to 10 kW, from farm-based biogas systems up to 400 kW, from residential wind turbine systems up to 25 kW and from farm-based wind turbine systems up to 125 kW. The net-metering program accept customers on a first-come, first-serve basis until the total net-metered solar-electric capacity equals to 0.1% of a utility's 1996 electric demand, the biogas system capacity equals to 0.4% of 1996 demand, and the wind system capacity equals to 0.2% of 2003 demand. Electricity from these systems will be purchased at the utility's avoided-cost rate except for the wind systems with a capacity higher than 10kW, which is credited at the state's avoided-cost rate.

Net Metering Rules in **Georgia** allow customers to sell all or part of the green power generated by their renewable-energy systems, include photovoltaic, fuel cells, and wind systems, up to 10kW for residential customers and 100kW for commercial customers. Utilities will purchase only up to the maximum capacity of 0.2% of the utility's annual peak demand during the previous year.

Net metering rules in **Pennsylvania** are currently being developed by the PA Public Utilities commission. At present, each utility is allowed to have its own net metering policy, and prices and operating procedures vary by utility. Currently, only owners of facilities less than 50 KW may qualify.

Evaluation
As a general statement net-metering has not become widespread even when it is available. Those contacted provided several reasons:

- In those state with low energy costs, net-metering does not represent a significant cost savings which would warrant the up-front capital and maintenance costs of installing renewable technologies.
- The uncertainty created in those states where there is no guaranteed purchase price, means few potential generators are willing to take the risk.
- Problems with interconnection are present in many states. These include who bears the costs or the interconnection and the requirements for interconnection. Some states have required through their Distributed Generation Acts or other legislation that utilities provide interconnection at no cost to the customer.
- Voluntary programs are of limited success if a utility already has a sufficient generating capacity or purchase agreements with other generators to meet its current or anticipated needs.
- Caps on the amount of electricity that utilities are required to buy back under net metering when set at low levels may limit the usefulness of net metering.

2. Renewable Energy Portfolio Standards (REPS)

Renewable Portfolio Standards (RPS) require that a certain percentage of the power either consumed or generated in the state must come from renewable sources. In its most basic form an RPS requires a utility to either generate, build or buy renewable energy as part of the mix of fuels it uses. Only 19 states in the United States have currently adopted RPSs. In the ARC region Maryland, Pennsylvania and New York have adopted RPSs.

The amount of renewable electricity to be included varies widely across the nation from 1 percent to 25 percent. New York, which already makes extensive use of hydropower, has the nation's highest percentage at 25. Maryland will ultimately reach 7.5 percent and Pennsylvania 18 percent.

RPSs are viewed as a means of introducing new technologies and additional competition into electric markets. Since most utilities have little experience with renewables, the RPS provides a means by which they can adopt these technologies. Since most renewable fuels have little environmental drawbacks, their use contributes to reduction of problems associated with air pollution. Reduction of dependence on imported fuels will have significant economic and national security benefits as well.

RPS can be met in several different ways. The utility can build its own renewable facility. It can purchase renewable power from other generators. A more recent development is the use of Renewable Energy Credits (REC). Under this system a utility which uses renewables can meter the amount of energy it creates. It can then sell RECs which designates that the generator produced one megawatt hour of electricity from renewable sources. Utilities which neither produce nor buy renewable energy can use RECs to meet their RPS requirement. Maryland and New York explicitly allow the use of RECs.

It is important to define what is included as renewables eligible for credit under a RPS. What is included in "renewables" vary considerably among the three ARC states which have adopted them. All included solar and wind. Hydro is usually included along with landfill gas. In a few cases waste from wood or coal, while not strictly renewable, are included. States such as Maryland and Pennsylvania divide their renewable fuels into two tiers. The RPS is to be met by employing a given percentage from each renewable source in each tier.

The greatest issue concerning RPS is the initial high capital cost of installation. Once the facility is in place the fuel costs are essential zero for wind, solar and small scale hydro. But the issue remains who is to bear these initial costs since they are often as much as three times those of the lowest cost natural gas fired power plant. This problem is particularly acute in states which have deregulated electric utilities and the company adopting renewable technologies may find itself at a competitive disadvantage. In states with traditional regulation, the question is will the regulators allow the higher capital costs to be part of the rate base. The National Council of State Legislators has estimated that the RPSs in the Pennsylvania and New York increase costs by only $3-$3.50 a year for the average residential customer.[22]

Objections which have been expressed concerning RPSs include utilities being forced to use technologies which are not fully technologically developed. Recent experience with renewable technology has demonstrated rapid deceases in costs and increases in efficiency. Forcing too early adoption under an RPS may be unwise until technologies are fully mature.

There is also concern given by some critics that RPSs add complexity to an already heavily regulated industry. These standards, particularly when tiers are employed, require extensive monitoring and oversight. The more detailed an RPS is regarding types of fuel, size of generators, percentage tiers for use of specific fuels and interconnection standards reduce the ability of renewable markets to fully function as utilities are restricted from finding and using the least costly renewable alternatives.

Maryland's RPS requires utilities to generate a given percentage of their power from renewable sources. This is a two tier program. The state's electric companies must obtain 1 percent of their electricity from renewable sources: solar, wind, biomass, anaerobic decomposition methane, geothermal, ocean, fuel cells and small hydro (less than 30 mw). The second tier consists of hydro (large scale), waste to energy facilities and poultry litter. The electric suppliers must get 2.5 percent of their electricity from these sources. The Tier one standard increases in increments of 1 percent until reaching 7.5 percent in 2019 at which time the Tier 2 standard disappears. The program also includes renewable energy credits (REC) of 200 percent for solar 110 percent for wind and methane. A supplier not meeting the RPS standards must pay into the states Renewable Energy Fund 2 cents per kWh for Tier 1 and 1.5 cents for Tier 2 shortfalls.

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[22] *National Conference of State Legislatures,* (June 2005) State Renewable Portfolio Standards: A Review and Analysis. Washington, DC. P.6.

New York's RPS stipulates an increase in the state's current 19 percent level of energy consumption from renewables to 25 percent. It is a two tier system with wholesale generators buying renewable credits from generators who use virtually any renewable or alternative fuel. Customers under the second tier are encouraged to install renewable generation capacity which can be sold into the grid for credit on their electric bills. The 25 percent target is divided into a mandatory 24 percent with 1 percent to be from voluntary generation under the state's Green Marketing Program.

Pennsylvania's Alternative Energy Portfolio requires that 18 percent of the electricity supplied come from alternative energy or renewables. The State uses the broadest definition of what fuels are included of any of the ARC states. In addition to the usual solar, wind, low-impact hydro, geothermal, biomass, methane and fuel cells, which constitute the Tier I sources, waste coal, distributed generation systems demand side management, municipal solid waste wood byproducts are included in Tier II sources. Starting in 2007 1.5 percent of supply is to come from Tier I and 4.2 percent from Tier 2. These percentages increase to 8 percent and 10 percent by 2020. Interconnection rules are currently under development by the State's PUC.

Evaluation

- RPSs have major benefits and deserve consideration in all ARC states. But the cost of requiring the use of renewable electricity in those ARC states with already below average electricity costs may pose difficulties particularly if the state uses its low energy costs as an inducement for economic development.
- States should not restrict the source of renewable power to generators within their boundaries. Political boundaries have little to do with the efficient allocation of electricity and will increase costs. Considering that all ARC states are interconnected to multi-state grids, such a requirement is not appropriate. None of the ARC states have such a limitation.
- Consideration should be given to using the broadest definition for renewable fuels. This will allow generators to seek the least costly source of renewable electricity. The advisability of tiers (and specific percentages within those tiers) and their impact on flexibility and costs should receive careful consideration.
- The regulatory environment as to how the initial costs are to be covered needs clear delineation. The policies in the ARC states now using RPS can serve as guidelines.

3. Public Benefits Funds

Public Benefit Funds go by different names in ARC states which have them. These are additional small charges to customers attached to their electric bills. The monies raised from these funds are used either for expansion of renewable energy, relief for low income households or promotion of energy efficiency.

The purpose of **New York's Systems Benefit Charge** is to collect a surcharge on the customers of the private utilities to support energy research, encourage energy efficiency and provide energy assistance to low income households. The charge may also be used to determine how to reduce the negative impacts of energy production and to increase competition in energy markets. During the five year period 2005-2010 the fund is estimated to receive $875 million. The program has demonstrated its effectiveness by reducing energy demand, saving utility consumers almost a quarter billion and generated almost $1.5 billion in energy investments. The fund traces significant reductions in air pollution and the creation of nearly 5,000 jobs to its projects.

Ohio's Energy Loan Fund (ELF) is financed by a surcharge collected from the state's four public utilities to provide low interest loans and loan guarantees for energy efficient upgrades at residential, governmental educational small commercial/industrial and agriculture facilities.

The five major private utilities in **Pennsylvania** have created **Sustainable Energy Funds (SEF)** which operate in their service areas. The specific programs supported by these funds are mentioned elsewhere in this report. The overall objectives are to promote renewable energy, advance clean energy technologies, encourage energy efficiency and support the clean energy business. Funds are collected from the customers by the utilities to support the programs.

4. Grant Programs

Grants as a means of encouraging the adoption of alternate or renewable technologies exist in many of the ARC states. A summary of sample state programs follows.

- **Alabama** has a **Renewable Fuels Program** to assist business in the installing of biomass energy system, this program offers participants technical assistance and subsidies up to $75,000 to cover the interest payment on loans to install approved biomass projects. But interest rate on the project should be no greater than 2% above the prime rate.
- **Kentucky** provides several grant programs focused on energy efficiency and alternate fuels. The **Energy Efficiency Education Grant** provided to the University of Kentucky gave $95,176 to promote energy efficiency education throughout the commonwealth. The **Kentucky Energy Efficiency Program for Schools Program** provided a $77,000 grant for the University of Louisville, which is aimed at managing the energy costs of schools in Kentucky. The program offers a complete package, including tools, curriculum, training, coaching and expertise to guide participating schools on how to reduce their energy costs and achieve energy efficiency. Further a $100,000 energy grant was awarded to the National Energy Education Development (NEED) Project for the design and delivery of an energy education program for teachers and students in grades K-12. **R&D Grants for Renewable Energy and Energy Efficiency** totaling $421,461for research and development grant renewable energy and energy efficiency initiatives, which include improved biomass

conversion, advanced aluminum melting systems, improved biodiesel product and enzymes for the conversion of corn-fiber to biofuels.

- **Kentucky** has also a $70,000 grant awarded to Kentucky Clean Fuels Coalition to establish a network of Kentucky public school bus fleet interested in using biodiesel or biodiesel blends and to manage the **Kentucky's Clean Cities Program**. The grant provides $42,000 for schools to compensate for the additional cost of adding biodiesel to school bus fleets.
- Under its **Assisted Home Performance Grants, New York** offers grants, up to $5,000 for single-home owners and $10,000 per building for 2-4 family units, to low-income residences for energy efficient improvement. **New York** further offers grant to support companies in the development, testing and commercialization of renewable-energy technologies that will be manufactured in New York. Funding varies by solicitation and is based in part on the likelihood that the technology will be competitive in the near future. Eligible technologies include solar thermal electric, photovoltaic, hydropower, alternative fuels, wind, landfill gas, and biomass.
- **Ohio** offers a **Fuel Cell Grant Program** which would use the $100 million budget to support fuel cells related research, project demonstration and job creation. The State offers **Dispersed Energy and Renewably Energy Grants** to commercial, institutional and industrial projects with a maximum capacity of 25 MW for up to $100,000 per grant. The program also provides grants to residential renewable-energy projects for up to $25,000 per grant and to non-residential projects for up to $150,000 per grant. A certain percentage of cost sharing is required for all grants. The. **Energy Loan Fund Grant for Energy Efficiency** provides funds to cover up to 25% of the total costs of projects that can improve energy efficiency by at least 15%. The maximum amount will be awarded is $50,000.
- **In Pennsylvania Metropolitan Edison Company SEF Grants** and **Penelec SEF of the Community Foundation for the Alleghenies Grant Program** established by First Energy, grant funds for the development and use of renewable energy and clean-energy technologies, energy conservation and efficiency, and projects that improve the environment. The grant amount varies according to project, but the maximum limit is $25,000. Also the **West Penn Power SEF Commercial Grant Program** provides funds to nonprofit companies and community-based organizations for the development and the use of renewable energy and clean energy. Grant amount varies by proposal.
- **Small Wind Incentives Program** offers funds to **Virginia** landowners for purchase and installation of small wind energy systems. The maximum award will be the lower of $10,000 or 33% of installed costs.

5. Loan Programs

ARC states also provide a variety of loans on very favorable terms for projects which use alternate or renewable energy or improve energy efficiency. Some of these are describes below.

- Under the **Solar Water Heater Loan Program** participating Eastern **Kentucky** counties are offering customers a 6-year payback term loan with 5% down payment and an interest rate of 3% to cover the total cost of a solar water heater for residential and commercial applications.
- **New York** provides three loan programs to its residents.
  - The **Home Performance with Energy Star Loan Program** offers up to $20,000 unsecured loan with a 5.99% APR to residential customers for the installations and developments of energy efficient and renewable resources measures. However, the measure has to meet the Energy Star qualifications to be eligible and the equipment must be installed by approved Building Performance Institute certified contractors.
  - The **Energy $mart Loan Fund** provides reduced-interest rate loans (4.0% below the lender rate for ten years; 6.5% below the lender rate for borrowers in the Liberty Zone) for lenders to fund projects to improve a facility's energy efficiency or utilize renewable energy systems.
  - Moreover, all facilities can also apply for the **Green Building Improvement Loan**, up to $500,000, if the facility has been registered for the LEED certification with the United States Green Building Council. The maximum loans for residential is $20,000; for multifamily and all other non-residential is $1 million plus $500,000 for Green Building Improvement; and for existing multifamily is $2.5 million, plus an additional maximum of $2,500,000 for projects that include advanced meters.
- **Community Energy Loan Program (CELP)** in **Maryland** offers loans to eligible local governments and nonprofit organizations, including hospitals and schools, to finance energy saving projects. On average, about $600,000 is available per loan and the current interest rate is approximately 3.5%. Organizations have up to 7 years to pay off the loan. By September 2005, 49 organizations have utilized this program, generating an annual saving of 2.4 million in the state. Also the **State Agency Loan Program** provides loans with 0% interest and a 1% administration fee for state agencies to fund energy efficiency improvements in state facilities. This program offers about 1 million in new loans each year. A total of $1.5 million was awarded to state agencies in 2005, estimated to generate savings of about $267,114 annually.
- The **Energy Investment Loan Program** in **Mississippi** provides loans ranging from $15,000 to $300,000 at an interest rate 3% below the prime rate, with a maximum loan term of 7 years, for renewable energy and energy efficiency projects.
- There are three loan programs established in **Ohio.**
  - **Double Saving Loan** provides loans up to $10,000, with interest-rate reduced by up to 50% through a linked deposit, to qualified residential borrowers with projects that improve energy efficiency in one- to three-unit residential building.
  - **Renewable Energy Loans** offers loans to Ohio residents, range from $500 to $25,000 and businesses, range from $5,000 to $500,000, to implement energy-efficiency or renewable-energy projects. Also, this

program will help applicants reduce interest rate by approximately half on standard bank loans.
    - **Business and Institutional Loans** are offered to businesses and institutions in Ohio. The loans will buy down the interest rate for energy efficiency projects, up to a maximum of $250,000 at a 50% reduced interest rate. Qualifying projects must reduce energy cost by at least 15% have an energy payback of 5 years or less and have an expected project life longer than the energy payback time.
- **Pennsylvania** has created four loan programs.
    - **Metropolitan Edison Company SEF Loans** is a fund established by FirstEnergy to promote development and use of renewable energy and clean-energy technologies, energy conservation and efficiency, projects that improve the environment. The loan amount may vary according to project, but the maximum limit is $1 million.
    - **Penelec SEF of the Community Foundation for the Alleghenies Loan Program** also established by FirstEnergy, provides loans up to $500,000 to promote the development and use of renewable energy and clean-energy technologies, energy conservation and efficiency, projects that improve the environment. The loan amount varies according to project.
    - **SEF of Central Eastern Pennsylvania Loan Program** provides a limited number of grants and loans to organizations needing funds for projects on research and development of clean and renewable energy technologies.
    - **West Penn Power SEF Commercial Loan Program (PA) –** offers commercial loans to manufacturers, distributors, retailers and service companies involved in renewable and advanced clean energy technologies, as well as energy efficiency and conservation products and services to end-user companies and community-based programs. The amount of loans varies by proposal.
- The **ConserFund Loan Program** in **South Carolina** offers loans to fund energy efficiency improvements in state agencies, local governments, public colleges and universities, school districts and non-profit organizations. The loans can help organizations cover up to 100% of eligible projects costs, from $25,000 to $500,000.
- **Local Government Energy Loan Program** in **Tennessee** gives low interest loans to municipal and county governments for energy efficiency-related projects in courthouse, administration buildings, schools, maintenance facilities, and any other building owned by the city or county. Eligible projects can borrow up to $500,000 at an approximate 3% interest rate for up to 7 years. The **Small Business Energy Loan Program** creates low interest loans of up to $100,000 for a maximum of 7 years payback time to businesses with fewer than 300 employees or less than $3.5 million in annual gross sales or receipts for renewable energy and energy efficiency projects.

6. Tax Incentives

Tax incentives are a frequently used method by state governments to induce a desired activity. Listed below are examples of ARC state programs which provide either deductions or credits to various taxes for use of renewable or alternative fuels as well as promoting energy efficiency.

a. Personal and Corporate Income Taxes: Deductions and Credits

- **Wood-Burning Heating System Deduction: Alabama** allows individual taxpayers to take the total costs of the installation of a wood-burning heating system or the conversion from gas or electricity heating system to wood as a deduction on their taxes.
- **Tax Modernization Plan;** The **Kentucky** Governor's 2005 tax modernization plan includes a $1.5 million tax credit to bio-diesel producers and blenders.
- **Solar and Fuel Cell Tax Credit: New York** offers a personal income tax credit for expenditures on solar-electric, solar-thermal and fuel cells equipment used on residential property, excluding the solar-energy systems used for pool heating or other recreational applications. The credit will equal to, 25% of the total costs of solar-electric and solar-thermal systems (up to $3,750) and 20% for fuel cells systems (up to $1,500). To quality for the credit, the systems are limit to a maximum capacity of 25kW for the fuel cells and 10 kW for the solar-electric. Additionally, the fuel cells systems must also utilize the proton exchange membrane (PEM) technology. Further the state has a **Green Building Tax Credit Program (Corporate & Personal)** which provides owners and tenants of eligible buildings and tenant spaces, which meet certain "green" standards, with tax credits of up to $2 million per building. The credit can be used against corporate taxes, personal income taxes, insurance corporation taxes or banking corporation taxes.
- **Maryland's Income Tax Credit for Green Buildings (Personal & Corporate)** enacted in 2001, applies to only non-residential and residential multifamily buildings of at least 20,000 square feet. The credit encourages the use of alternate energy systems, such as PV, wind turbines and fuel cells. The tax credit amount differs depend on building type and renewable energy systems, for instances, 6-8% of the costs of construction or rehabilitation for green building, 20-25% for PV and wind systems and 30% for fuel cells systems. To be eligible, the buildings must meet specific environmental and energy requirement, but the renewable-energy system size is not specified.
- **Renewable Energy Tax Credit (Personal & Corporate)** provided in **North Carolina** offers a 35% tax credit for the cost of renewable energy property in North Carolina. The ceilings for the credit vary depending on the sector and the type of renewable-energy system. The maximum for

different technology used in residential facilities are between $3,500 and $10,500 and in commercial and industrial facilities is $2.5 million.

- **West Virginia** has enacted a **Business and Occupation Tax Reduction** from 40 percent of generating capacity to five percent.

b. Sales Tax

- **Georgia** under its **3-Day Sales Tax Exemption** exempts the sales of any qualifying energy efficient residential appliances (under $1,500) that meets or exceeds the "Energy Star" program requirements, sold between August 03 and August 06, 2006, from the state sales and use taxes, but not local sales taxes. In addition the State provided a sales tax exemption on purchases for non-commercial, home and personal use energy efficient products, under the price of $1,500, purchased between October 6 and October 9, 2005.
- **New York** has a **Solar Sales Tax Exemption** applied to sales and installation of residential solar-energy systems, which utilize solar energy to provide heating, cooling, hot water and/or electricity, from the state's sales and use taxes.
- There is in **Maryland** a **Wood Heating Fuel Exemption** from the sales tax on all purchase of wood or "refuse-derived" fuel, used for heating in residential buildings.
- A **Conversion Facilities Tax Exemption** exists in **Ohio** which exempts certain equipments used in energy conversion, such as thermal-efficiency improvements and the conversion of solid waste to energy, from property tax, the state's sales and use tax and the state's franchise tax where applicable.

c. Property Tax

- According to **New York's Solar, Wind & Biomass Energy System Exemption** solar, wind energy and farm-waste energy systems (limit to a maximum capacity of 400kW only), constructed in New York State prior to July 1, 1988 or between January 1, 1991 and January 1, 2006, and were eligible for a 15-year real property tax exemption. The amount of exemption will equal to the increase in assessed value attributable to the renewable energy system.
- A **Corporate Property Tax Credit** allowing counties in **Maryland** to provide tax credits to corporate or property tax when solar, geothermal and other qualifying alternate energy systems are used for heating or cooling. The tax credit amount and the length of the credit vary, because counties have the autonomy to decide on the amount of credit and length of time up to a maximum of 3 years. In addition the State permits solar heating and cooling systems to be assessed at no more than the value of a conventional system for property tax purpose and a full property tax exemption for solar energy equipment.

  - The **North Carolina Active Solar Heating and Cooling Systems Exemption** program exempts active solar heating and cooling systems, placed on residential, commercial and industrial property, from being assessed at more than the value of a conventional system for property tax purposes.
  - **Wind Energy Systems Exemption** in **Tennessee** was enacted in 2003, providing that wind energy systems operated by public utilities, businesses or industrial facilities shall not be taxed at more than one-third of their total installed cost.
  - **Virginia** allows a **Local Option Property Tax Exemption for Solar** which any county, city or town may exempt or partially exempt solar energy equipment or recycling equipment, installed in residential, commercial or industrial property, from local property taxes.
  - For the installation of wind farms **West Virginia** provides a **Property Tax Assessment Reduction** for utility wind turbines which lowered the property tax from 100 percent to five percent of assessed value.

7. Rebate Programs

Another way that ARC states promote alternative, renewable and efficient energy is by offering rebates under the programs outlines below.

- **Biomass Energy Interest Subsidy Program** in **Alabama provides** reimbursement of interest to property owners on loans for installing biomass energy system.
- The following rebate programs exist in **New York**
  - **Small Commercial Lighting Incentives Program** offers incentives, up to $30,000, for businesses to install effective and energy-efficient lighting in small commercial spaces. Under this program, lighting contractors, distributors, manufacturers, and designers are also eligible for various incentives associated with bringing energy-efficient lighting to small commercial spaces.
  - **Wind Incentive Program** develops a network of eligible installers who will install end-use wind energy turbines for facilities in all sectors, the incentive program offers up to $100,000 per installation to eligible installers. The incentives are paid based on a percentage of the installation cost (50% of costs for systems of 500W to 10kW; 15% for systems larger than 80kW and 70% for commercial customers).
  - Under the **$mart Equipment Choices Program** applicants are eligible for rebates up to $10,000 for installation and replacement of electric efficiency equipment and up to $25,000 for gas efficiency equipment in non-residential structures.
  - **Energy $mart New Construction Program** promotes the incorporation of energy efficiency and renewable energy resources in the design, construction, and operation of commercial, industrial, institutional and multifamily building, the NYSERDA has a 10 million budget for this

program to provide incentives up to $375,000 per project for Whole Building Design projects and up to $120,000 for most other projects.
    - **PV Incentive Program** provides incentives of $4 to $4.5 per watt, based on direct-current (DC) module rating, to eligible installers for the installation of approved, grid-connected PV systems that has a maximum of 50kW capacity. The total budget available for this program has been raised to 12 million in 2005.
    - **LIPA Solar Pioneer Program** offers rebates for approximately 50% of the costs of a PV system with a maximum of 10kW capacity. As the overall price of PV system has been decreasing, the program has adjusted its rebate from $5 per watt for the 1000kW of PV installed to $3.75 per watt (DC) for the next 1,000kW block for residential and commercial customers and $4.75 per watt (DC) for schools, nonprofits and government agencies.
- **Maryland's Solar Energy Grant Program** provides funding for homeowners, businesses, local governments and non-profit organizations to install solar water-heating and solar-electric (PV) systems. The reimbursement is 20% of the equipment cost (up to $3,000 for residential property, $5,000 for commercial property and $2,000 for solar water-heating equipment). Systems have to meet the minimum size requirement set by the U.S. Department of Energy to be eligible. The **Clean Energy Rewards Program** approved by the Montgomery county council offers residents and businesses incentives for buying clean energy. However, the reward levels and incentive rates have yet to be set.
- **Sustainable Development Fund Solar PV Grant Program** issues rebates to PECO customers for purchase of PV systems. The grant is paid based on system performance and customer type. For example, $4 per watt up to $20,000 is the buy-down incentive for the PV system owner; $1 per kWh in the first year up to $5,000 is the performance incentive for PV system owner; and $0.1 per kWh in the first year up to $250 is the performance incentive for the participating contractor.
- **Residential Solar Initiative for EarthCraft Homes Rebate** in **South Carolina** offers homebuilders a rebate for every home built with a solar hot water heating system. A maximum of $20,000 in total rebates has been allocated for this program, so a total of 20 rebates of $1,000 each will be awarded to builders for approved new installations.
- Under **Kentucky's Solar Water Heater Rebate Program** the Kentucky Solar Partnership is offering a $500 rebate for solar water heaters installed on residences. The budget is available for 25 installations in total.

8. Other Programs

The **TVA** has established a **Green Power Partners Program** in its service territory. Green power consists of electricity generated from renewable sources. Green Power is sold in 150 kWh blocks which is about 12 percent of an average households use. The cost is four dollars ($4) for each block. The green power used is from the TVA's 18 wind turbines, 16 solar facilities and one methane plant. No expansion is currently planned as there is a 30 percent surplus of unsold green power available.

Clean Energy Procurement programs require that public bodies obtain a certain percentage of their electric power from renewable sources. Maryland requires state owned facilities to acquire 6 percent and 11 cities in Maryland and one county have established 5 percent requirements. New York's requirement is 10 percent. Several localities in ARC states also have renewable procurement standards.

Solar Easement Guidelines have been established in Georgia, Kentucky, Tennessee and Virginia. These allow owners of solar systems to obtain easements which insure access to direct sunlight to operate their systems. These restrictions would limit new construction or other impediments to be constructed which block sunlight.

9. Policy Recommendations

ARC should consider policy alternatives related to alternative and renewable fuels for its support which will produce the most impact for the limited dollars available and which do not duplicate efforts of other entities. These could include:

- Best Practices Data Base. Included would be examples of what has worked well and why. These should be case studies regarding the use by public and private entities of renewable and alternate energy as well as energy efficiency programs. The payoffs from energy efficiency programs, use of renewables and deployment of dispersed energy generation are impressive. These quick pay-offs should be a powerful incentive for more widespread adoptions. But these examples need to be catalogued, updated and references provided.
- Model Legislation. While not impossible it is difficult to find regulations and legislation which relate to energy efficiency and use of renewable and alternative fuels. A compendium of state practices including legislation, regulations and capsule summaries would facilitate those searching for examples upon which to base their own deliberations. This effort should be comprehensive including, but not being limited, to policies toward:
    - Renewable Portfolio Standards (RPS) including interconnection requirements
    - Regulation of biofuel production
    - Biofuel purchase guarantees
    - Green Building incentives
    - Wind farm siting
    - Regional transportation plans
    - Promotion of distributed generation
    - Renewable Energy Production Credits (REPC)
    - Energy efficiency programs and policies.
    - Taxes and subsidies.
    - System Benefit Funds (SBF)

    - Energy Efficiency Resource Standards (EERS)
    - Productive incentives for landfill methane
    - Net metering.
    - Energy workforce development
    - Energy education
- Research on Policy Effectiveness. It is surprising that very little solid research exists on what is and what is not effective. Most state programs have no basis to claim success or failure. While anecdotal information exists, it does not establish which programs produce the greatest results for the dollars expended. As state budgets continue to tighten and energy programs must compete with other demands this information is vital for effective public policy.
- Transmission Problems. While considerable attention is paid to increasing production of energy from renewable and alternative sources as well as the retail distribution of energy, less attention has been paid to the "missing link" of transmission and wholesale distribution. Even if more electricity could be generated from renewables and alternate sources, the level of congestion on the grid limits its availability. The ability to distribute biofuels at the retail level will be a problem when production increases due to the lack of infrastructure. ARC has a comparative advantage is this area because of its work with the highway corridors program.
- Technology Exchange. Most developing technologies are not familiar to state policy makers. Poorly understood technologies are not likely to be encouraged. Sufficient expertise exists among the regions universities, state energy offices, energy producers and consumer organizations, that this information should be widely available. Having experts identified in each of the appropriate areas would be a significant benefit as states grapple with the energy environment.

Chapter III. State of Technology and Manufacturing in Appalachia

1. Wind

Today's wind turbines are much larger and more efficient than those of the 1980s. Today's turbines produce much more power and also require a larger physical footprint. Modern turbines for offshore use are as large as 5 MW each while in the early 1980s a typical turbine was 25 to 100 KW. Deployed turbines for on land use typically range from 700 KW to 2.5 MW. Costs have declined by about 90 percent over the last 20 years, mostly from capital cost decreases and efficiency improvements.[23]

As rotor diameters have gotten longer, increasing from about 10 meters in early 1980s to over 80 meters today, capacity and energy production actually increased as a faster rate. This recent development of larger turbines has made Appalachian wind more attractive to commercial developers due to the greater quantity of electricity that can now be generated per turbine as well as improved availability. Turbines up to two MW in size, such as those installed at the Bear Creek Wind Farm in Pennsylvania, or the 2.5 MW turbines proposed for Clipper project in Garrett County, MD, are among the largest on-shore turbines in the world. Due largely to the State of Pennsylvania's active policy toward wind development, wind-energy company **Gamesa Corp.** of Spain selected an industrial park in Ebensburg, PA as the site for its U.S. blade manufacturing facility. The increased size and height of turbines has spurred debate over the issue of "viewshed" impacts from wind installations. Larger turbines have hub heights over 300 feet and are thus visible from further distances compared to older, smaller turbines that may have been only 30 to 40 feet tall.

Wind energy efficiency improvements have included use of advanced electronics to develop variable speed turbines and longer lived turbines. Systems integration improvements have induced system operators to give wind capacity credit on the electricity grid, increasing the viability of wind projects. New R&D on low-speed land-based turbines can help take advantage of lower speed winds, which have applicability throughout the Appalachian region.

Wind system parts manufactures in the region include **CAB Inc. (**bearings, nacelle frames and shafts), **Hodge Forge (**bearings, gearboxes and nacelle frames) and **Motors and Controls International** (generators) in Pennsylvania, and **Hilliard Corp.** (brakes) of Elmira, New York.[24]

[23] American Wind Energy Association, 2005.
[24] Glasmeier, A and Tom Bell (2006). "Economic Development Potential of Conventional and Potential Alternative Energy Sources in Appalachian Counties."

Other wind-related manufacturing activity in the ARC region includes **General Electric**'s wind turbines R&D facility in Greenville, SC. That location does wind turbine fleet support engineering focused on the generator and other electrical components.

Magna Machine in Cincinnati, OH is a manufacturer of blade hubs. Its proximity on the border of the ARC region promises potential synergies with manufacturers in Appalachian.

2. Solar

The primary barrier to widespread installation of solar energy conversion systems is price. Photovoltaic (PV) systems are still expensive. Through June of 2006, solar electricity generation costs averaged 38 cents per KWh for residential systems, 28 cents per KWh for commercial systems and 22 cents per KWh for industrial systems.[25] Current systems are also still fairly inefficient: thin-film cells are less than 10 percent efficient and crystalline-silicon cells are 12 to 14 percent efficient. Further improvements in efficiency would allow the less intense sun areas of the Appalachian region to get more power from a PV cell. Other issues that continue to stymie expansion include low component manufacturing rates; the industry has a goal of creating a 200 MW factory by 2020. Silicon production is also expensive and a larger supply chain is needed. In spite of these issues, PV production costs have fallen by 100 times since the mid-1970s.[26]

Breakthroughs in system integration have improved the ease of maintaining solar systems which promotes usability. In addition, marketing of solar systems in nationwide stores such as Home Depot has also made the technology more accessible.

Other means of capturing solar power, such as concentrating solar power, where thermal solar energy is collected as heat and directed toward a conventional power generating system, have also made progress but are less applicable to the Appalachian region. Since the 1980s DOE R&D support has allowed the costs of this type of system to decline considerably while also improving efficiency.

Solar manufacturing and solar R&D activity in the Appalachian region is concentrated in Pittsburgh area. **Plextronics Inc.** conducts research to manufacture polymer cells that are thinner, lighter and more flexible than current PV cells. Polymer cells are made from regioregular polythiophenes, self-assembling nanoscale conducting polymers. This type of PV cells has the potential to be more cheaply produced (printed) than other PV cells. **Plextronics** was founded in 2002 as a spin-off from Carnegie Mellon University's McCullough Lab.

A firm by the name of **Solar Power Industries, Inc**. in Belle Vernon, PA makes crystalline cells, primarily for the gardening products market.

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[25] Solar Electricity Global Benchmark Price Indices, July 2006 Survey Results. Solarbuzz, LLC http://www.solarbuzz.com/solarprices.htm
[26] U.S. Department of Energy, Solar Energy Technologies Program.

AFG Industries’ Blue Ridge Plant in Kingsport, TN is a flat glass manufacturer that supplies BP Solar, Shell Solar and GE Solar with photovoltaic glass.

There are several other solar manufacturers that are in ARC states but not in the ARC region, that are worthy of mention. These include **Atlantis Energy Systems, Inc.** in Exmore, VA that makes building integrated PV products including PV roofing slates and PV glass laminates and **BP Solar** in Frederick, MD, which is one of the larger PV panel manufacturers in the country.

3. Geothermal

Most recent geothermal technology improvements have been related to system design. Some increased efficiency has also been seen but most improvements are due to the way air and water is delivered from the ground to the building. Staging and zoning of delivery have become more sophisticated, which has reduced the costs of supplying geothermal heating and air conditioning to multiple zone buildings. This resource has significant potential to improve the overall efficiency of heating and air conditioning related energy use if applied in more buildings and residences.

There are two geothermal system design companies in the ARC region. Both of these are in Pennsylvania: **Sunteq/Enviroteq** in State College, and **Hydro Delta Corp.** in Monroeville. Both companies design, build and install custom geothermal systems designed for specific applications. Enviroteq manufactures compressor units, with up to three stages of heating and cooling that interface with conventional air handlers. Hydro Delta manufactures a broad range of heating, cooling and water heating systems, including on-demand water heating equipment, and was the industry's first manufacturer to custom-insulate tube-in-tube heat exchangers to prevent condensate from forming on the outer surfaces.

4. Small and Low Impact Hydro

Modern hydroelectric technology has made progress in several areas. Overall, a major aspect of advancement has been in improved hydrologic assessment and project identification. Standardized design of turbines and generators also allows for greater ease of operation and maintenance.

Modern turbines also perform better regarding environmental impact. Newer turbines contribute less to fish mortality, with advanced turbine technology such as that supported by the DOE’s Wind and Hydropower Technologies Program having the ability reduce fish mortality resulting from turbine passage to less than two percent, in comparison with turbine-passage mortalities of 5 to 10 percent for the best existing turbines and 30 percent or greater from other turbines. Newer turbines also have improved compliance with water quality standards in terms of maintaining required downstream dissolved oxygen levels.

The study team was not able to locate any regional firms that specialize in small-scale or low impact hydroelectric installations.

5. Biomass

Biomass energy recovery systems utilize mature technology. The primary barriers to its further development are policy and knowledge based. Landfill gas systems, for example, are comprised of common commercial piping and compressions systems and generators. Eight of the 13 ARC states currently have landfill gas projects within the region's counties that are used both for generating electricity and for direct methane use. The States of West Virginia, Ohio, Maryland, Virginia and Mississippi do not have landfill gas projects within the Appalachian region.[27]

There is already about 885 MW of installed biomass-based electric generating capacity in the ARC states. This figure includes 248 MW of landfill gas capacity and about 637 MW of other solid biomass-based generators including wood waste and other biomass solids.[28]

6. Biofuels

Cost is the primary barrier to widespread use of domestically produced biofuels. However, many states are providing financial incentives to overcome this barrier.

There are several biofuels production facilities in Appalachia and the development of biofuels is a large focus of many state energy plans in the region. Ten manufacturers have a combined production capacity of over 133 million gallons per year.

- The State of Kentucky is implementing a large-scale effort to power its school buses with biodiesel. Producers in the ARC region are:
  - **Green Earth Bio Fuels** is building a 3.2 million gallon biodiesel plant in Irvine, KY.
  - **Owensboro Grain** is building a 50 million gallon biodiesel plant in Owensburg, KY that uses a combination of feedstocks.
- The State of Georgia has two biofuels producers in the region. These are:
  - **U.S. Biofuels** uses chicken fat to produce three to five million gallons of biodiesel a year in Floyd County, GA.
  - **Peach State Labs** in Rome, GA produces soybean based biodiesel and has production capacity of 36 million gallons.

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[27] The Berkeley County Solid Waste Authority in West Virginia had a landfill gas to energy project from 1985 to 1996 that was a direct use line to a nearby Veterans' Administration hospital. The landfill was forced to close in 1992 following a lawsuit by a private landfill operator.

[28] Energy Information Administration, 2005. Annual Electric Power Industry Database (Form EIA-860) from http://www.eia.doe.gov/cneaf/electricity/epa/epat2p2.html.

- The State of Alabama has two biodiesel producers in the region:
    - **Alabama Bio-Diesel** in Moundville, AL uses soybean oil to produce 24,000 gallons of biodiesel per year for the Birmingham Airport Authority, with plans to triple production.
    - **Future Fuels** in Haleyville, AL produces about 234,000 gallons of soybean oil-derived biodiesel per year.
- The State of Pennsylvania has two biodiesel producers in the region:
    - **Capital Technologies International** in Pittsburg, PA has a 10 million gallon capacity plant that can use a combination of soybean, corn, and canola oils, as well as used cooking oil and animal fats
    - **United Oil Company** of Pittsburg, PA has a 2 million gallon capacity multi-feedstock biodiesel facility
- The State of Ohio has one ethanol plant in the region:
    - **Harrison Ethano**l in Cadiz, OH has a 20 million gallon capacity. This project includes a plan to raise cattle on-site which will be fed grain from the plant. Use of anaerobic digesters to process manure is also planned.
    - **South Point Ethanol** in South Point, OH is an antiquated facility that closed in 1995.
- The State of South Carolina has one biodiesel facility and it is in the region:
    - **Carolina Biofuels, LLC** in Taylor, SC produces biodiesel from soybean oil and has an annual capacity of 7 million gallons.

This list of firms may not be comprehensive and does not include supplier chain businesses.

Chapter IV. Hydrogen R&D

Hydrogen research and development (R&D) is focused in several major categories: production, use, delivery and storage. In all areas, research includes some focus on basic science as well as practical application. Hydrogen production from natural gas and less commonly through electrolysis already occurs in a number of industrial settings, where it is quickly transformed into other products. Its production is costly and is not efficient enough to justify its use over direct use of the fossil feedstock. Hydrogen also cannot yet be practically stored in a way that makes distribution possible.

Hydrogen production R&D is being pursued in several parallel pathways. It has not yet been determined what method of production is the most efficient and sustainable. In the renewable arena several methods are under evaluation: reforming bio-gas, water electrolysis from electricity generated from renewable resources, biological production from algae, and several types of early-stage direct solar applications including photoelectrochemical and thermochemical production. Research on other methods of separating hydrogen from fossil fuels include natural gas reforming, coal gasification and nuclearchemical cycles as well as other basic materials research is also underway.

Production of hydrogen from renewable energy resources is most likely to come from electricity produced from those resources. Electrolysis, a process whereby electricity is used to separate hydrogen and oxygen in water, produces hydrogen with water as a by-product. Alkaline electrolysis systems are mature and commercial, although quite expensive and only used in niche processes. Proton exchange membrane systems are even more costly and need improved durability. Both types need greater efficiency. Other barriers are of course, the cost of renewable electricity itself and the intermittency of that power. Electrolysis also requires constant supply of clean power.

Hydrogen storage research is pursuing several potential storage mediums including high-pressure compressed storage, chemical storage and materials-based storage such as carbon, boron and metal hydrides. Storage, both for distribution and on-board vehicles, is a key component of a hydrogen-based economy.

Hydrogen use is likely to achieve the highest potential efficiency via fuel cells. Separate research on this energy conversion device is also underway, but is not discussed here. Fuel cells are also quite expensive to produce and do not yet have the durability and efficiency necessary for widespread use.

At least 15 hydrogen research projects are underway in the Appalachian region. The most concentrated research effort takes place at Oak Ridge National Laboratory in Tennessee. Research also takes place in several of the major universities in the region, with much of that work conducted at the Pennsylvania State University and the University of Alabama. A portion of this research is described below, with research on renewable hydrogen production discussed first.

1. Solar Hydrogen Production[29]

Several types of early stage research are underway on the potential production of hydrogen using solar heat to induce water electrolysis to separate hydrogen and oxygen. These include photoelectrochemical production, whereby water is split directly upon illumination using semiconductor materials and thermochemical production, whereby water is split as chemical or metal compounds e.g. sulfuric acid, metal sulfate, or metal oxides, interact with water to produce hydrogen. Solar concentrating systems could provide heat for these processes. Another very early-stage research area is photobiological production, whereby hydrogen is produced from unicellular green algae or cyanobacteria that live on solar energy.

Hydrogen research in the Appalachian region based on production from renewable energy is concentrated in solar applications and includes:

- Pennsylvania State University –
    - observation of the efficiency of solar electrolysis by isolating single crystal silicon photovoltaic cells.
    - development of novel silicon and cadmium selenide nanowire for water splitting
    - development of “A Hybrid Biological/Organic Half-Cell for Generating Hydrogen”
- Virginia Polytechnic Institute and State University –
    - studies of trinuclear, rhodium-centered mixed-chemical complexes for water splitting.
- Oak Ridge National Laboratory –
    - Research to increase the rate of algal hydrogen production by designing a proton channel to stabilize proton activity during production, thus removing a physiological obstacle to efficient conversion of light energy.
- Marshall University (Huntington, WV) –
    - Adaption of photosynthesis to the production of hydrogen from algae.[30]

2. Non-Renewable Hydrogen Production R&D[31]

Much hydrogen research is also focused on production from fossil fuels.

- Oak Ridge National Laboratory –
    - Fossil Hydrogen Production: Use of microporous inorganic membranes to separate hydrogen from a synthesis gas (possibly coal derived) at certain pressures and temperatures.

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[29] U.S. Department of Energy (2005). “Solar and Wind Technologies for Hydrogen Production,” Report to Congress. http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/solar_wind_for_hydrogen_dec2005.pdf
[30] The lead researcher on this project, Dr. Sergei Markov, is no longer with Marshall University.
[31] http://www.hydrogen.energy.gov/annual_review06_delivery.html#electro

    - Nuclear Hydrogen Production: This method attempts to extract hydrogen from water at a low-temperature reaction – between 650C and 750C – through the use of a sulfur dioxide reaction and use of microporous membranes.
- Media and Process Technology, Inc. (Pittsburgh, PA) –
    - Use of a carbon molecular sieve membrane as reactor for water gas shift reaction. This method takes carbon monoxide and water through high temperatures into a ceramic membrane that facilitates the creation of carbon dioxide and hydrogen.
- Ohio University –
    - This project tries to tackle the problems of hydrogen sulfide in syngas derived from coal into the creation of solid oxide fuel cells through the use of specialized anodes.

3. Hydrogen Storage R&D[32]

- Pennsylvania State University's Carbon Center of Excellence –
    - Use of boron in metal loaded high porosity carbon materials for the reversible storage of hydrogen.
- University of Pittsburgh's Metal Hydride Center of Excellence –
    - Computational work on finding workable alloys in metal hydride systems.
- Oak Ridge National Laboratory –
    - Research on the use of carbon for the storage of hydrogen, including of carbon-based solutions and compounds.
- University of Alabama's Chemical Hydrogen Center of Excellence –
    - Evaluation of the chemical storage of hydrogen using carbenes and cyanocarbons, both types of electron deficient molecular compounds.
    - Evaluation of the use of boron in the storage of hydrogen.

[32] http://www.hydrogen.energy.gov/annual_review06_storage.html

Chapter V. Corporate Energy Efficiency and Renewable Energy

The following facilities in the ARC region are examples of the use of energy efficient processes and renewable energy in corporate settings. These cases highlight innovative implementation of waste reuse and energy saving system design. Some of these examples are Federal facilities that have reduced energy consumption through the Department of Energy's Federal Energy Management Program (FEMP). Others are partners in the DOE's Industrial Technologies Program.

1. Dublin, Virginia - Volvo Trucks

Volvo's New River Valley Plant is the largest Volvo Trucks manufacturing facility in the world and assembles all Volvo trucks sold in North America. This facility also makes electric cabs for Volvo's emerging line of fully electric cabs for long-haul trucks. In recent years, the New River Valley plant has made considerable changes in its industrial processes that have focused on reducing consumption of water, energy and materials, while increasing recycling and minimizing waste material. The facility utilized the Siemens Energy Management Program to reduce energy usage through the automation of lighting and building heating and cooling.

Photo: Volvo Trucks New River Valley Plant

Since 2003, the plant has reduced water consumption by half through recycling and reuse of water used for cab leak testing and in painting. A recycling program and increased sorting of refuse cut landfill waste in half since 2000; the plant currently recycles more than 75% of the waste it generates. The amount of energy consumed for each truck produced has dropped by more than 60% since 2001, through a comprehensive energy management program. The facility was awarded the 2005 Governor’s Environmental Excellence Award for its efforts to reduce emissions. These include replacing all paints and lacquers with lead and chromium-free products.

2. Radford, Virginia - Radford Army Ammunition Plant

Photo: Radford Army Ammunition Plant

This 4,080 acre manufacturing area supplies solvent and solventless propellant and explosives to the U.S. Armed Forces. The facility undertook an energy savings program that emphasized low cost energy conservation initiatives. Much of the savings were due to increased nitrocotton/ nitrocellulose production, which reduced the magnitude of steam line losses as a percentage of total plant steam. Other projects included installing an oxygen trim for powerhouse boilers, reducing reactive power charges from their utility, and varying steam turbine extraction pressures. The facility’s energy saving projects allowed cost savings of more than $350,000 and 230 billion btu per year.

3. Hagerstown, Maryland – Statton Furniture

Statton Furniture is a manufacturer of quality, hand-crafted cherry furniture. The company has operated since 1926. Since 1973 the company has utilized over 40 percent of its wood waste by using this fuel source to operate a boiler within the company's plant facility. The wood waste used to run the boiler is transferred from the company's wood saws to storage where it is eventually fed to the boiler unit. The unit is currently used to heat the entire plant facility. The plant's utilization of wood waste enables the plant to obtain a 60 percent yield on lumber.[33]

4. Huntington, West Virginia - Steel of West Virginia

Steel of West Virginia is a supplier of structural beams, channels and special shape steel sections made of recycled steel. The company is one of three mills in the U.S. that uses a laser gauge to photograph steel bars for defects, allowing considerable time saving for that stage of production.

Over the past few years, Steel of West Virginia has spent more than $60 million to modernize its production process. Due to the energy-intensive nature of the operation, virtually every upgrade was related to energy consumption. Upgrades included a new high-speed reheat furnace, quick-change mill roll stands, installation of finger doors on furnaces and a reduction in the amount of time gas torches were on. As a result of these investments, productivity doubled and the facility has seen annual energy savings of $1.6 million or more. Current plans include more energy saving improvements, including the elimination of one of two scrap melting furnaces, without reducing capacity.

Photo: Steel of West Virginia

[33] Interview with Bill Whittington, plant manager, July 11, 2006.

5. Spartanburg, South Carolina - BMW Manufacturing

BMW manufactures its X5 Sports Activity Vehicle, Z4 Roadster, M Roadster, Z4 Coupe and M Coupe at its Spartanburg facility. The facility gets 53 percent of its energy needs from methane gas from a nearby landfill. A 9.5 mile pipeline from the landfill feeds the gas directly to the facility, where it is used to power BMW's generators and paint shop oven burners. The paint shop is the largest energy user within the BMW facility. The installation has saved BMW over $1 million in annual energy costs and reduces the company's exposure to volatile natural gas prices.

Photo: BMW Manufacturing

6. Tishimingo, Mississippi – Heil Environmental

Heil Environmental manufactures refuse truck bodies for the garbage collection industry. Following an energy assessment conducted by the Mississippi Development Authority and implementation of recommended upgrades, the company reported annual savings of $500,000. The savings were a major factor in the decision to keep the facility open and the resulting additional investments made in more efficient equipment and building upgrades.[34]

7. Russell, Kentucky - AK Steel, Ashland Works

AK Steel's Ashland Works produces carbon and ultra-low carbon steel slabs, along with hot dip galvanized and galvannealed coated steels. AK Steel recently installed a new briquetting process to recycle and reclaim up to 250,000 tons per year of iron and carbon

[34] July 2005 correspondence to the Mississippi Development Authority from the Tishomingo County Economic Development Authority.

units, reducing the amount of raw materials that must be purchased. The facility also implemented several conservation and efficiency measures that reduced natural gas consumption per ton by approximately three percent since 2003. These cost savings have helped the facility to remain a player in an increasingly competitive international steel market.

Photo: AK Steel's Ashland Works

8. Uhrichsville, Ohio – Commonwealth Aluminum/Aleris Rolled Products

Commonwealth Aluminum manufactures alloy aluminum sheet from recycled aluminum and aluminum and nonmetallic wiring products. The company's Uhrichsville plant is a continuous-casting mini-mill. Commonwealth Aluminum is a partner with the State of Ohio and the U.S. Department of Energy's Industrial Technologies Program.

Results of the energy assessment identified several upgrades that could save the facility more than $1 million per year. These included upgrading the melter/holder furnaces, improving the melt stirring process, implementation of best practices for melting and use of infrared imaging technology for process diagnostics. Several of these upgrades would have an immediate payback, while upgrading of the melter was estimated to give a five year payback.

9. Ragland, Alabama - Ragland Clay Company

Ragland Clay Company is a manufacturer of brick and brick paver products. The company has been making extensive modifications and improvements to their plant since 1996. One of the most recent changes is the use of a biomass gasification unit that uses wood chips as fuel. The gasification unit was installed in order to reduce energy costs and to reduce moisture in the bricks themselves leading to a higher quality product. The gasification unit has been in use for less than three months making exact energy savings difficult to measure. However, it is estimated that the new unit will result in an energy savings that will range from $400 to $600 per day.

10. Freeland, Pennsylvania – Hazelton St. Joseph Medical Center

This 6,500 sq ft facility is heated and cooled with a geothermal air conditioning system. The system is comprised of two five-ton and one 7.5 ton water-to-air heat pumps. Six 220-foot vertical boreholes deliver constant temperature air via circulating groundwater loops all year round.[35] This system has caused the center's energy costs to be lower than comparably used smaller sized buildings.

Photo: Hazelton St. Joseph Medical Center

11. Vestal, New York – Kopernik Space Education Center

Installation of a geothermal HVAC system in this 8,000 sq ft building allowed the Roberson Museum and Science Center to expand its astronomical observatory and improve its energy efficiency without having to build a natural gas pipeline to the relatively remote hilltop where the observatory is located. The system includes eight circulating tubes drilled 250 deep into granite bedrock. The payback on the system relative in terms of energy savings over a conventional system was about six years.[36] This investment was made possible through a grant from the State of New York.

[35] http://www.geoexchange.org/pdf/cs-021.pdf
[36] http://www.geoexchange.org/pdf/cs-066.pdf

Photo: Kopernik Space Education Center

12. Burnsville, North Carolina – EnergyXchange Renewable Energy Center

This demonstration facility uses landfill gas to fuel a pottery kiln, glass furnace and a regional forestry and horticulture center. The complex also includes a micro-turbine demonstration of electricity generation in partnership with Carolina Power and Light. The project is an example of a combined Federal, State and private partnership.

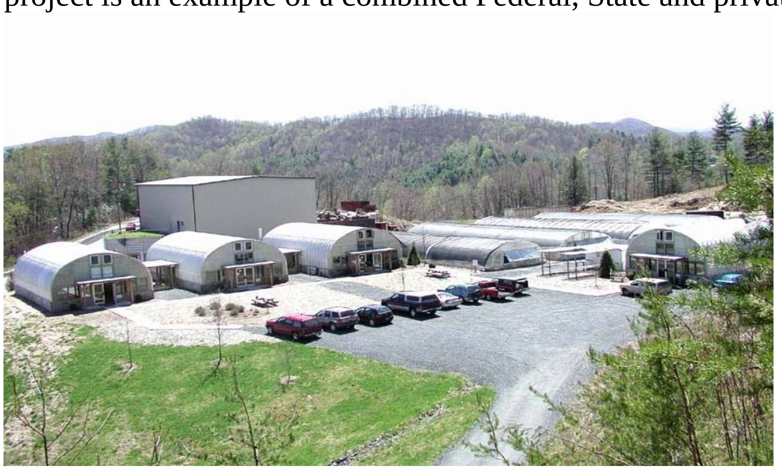
Photo: EnergyXchange Renewable Energy Center

13. Knoxville, Tennessee – Rohm and Haas Company

Rohm and Hass is a specialty chemical manufacturer that provides products to a number of industries including paints, electronics, adhesives and plastics manufacturers. The company is a partner with the U.S. Department of Energy's Office of Industrial Technology energy assessment program. Rohm and Hass's energy assessment identified potential energy savings in steam and electricity use equivalent to $1.5 million in cost savings. Energy savings implementation as of 2003 included 20 billion btu per year in fuel savings and 1,600 MWh per year in electricity savings. Specific identified energy projects included: optimization of steam system maintenance, recovery of preheated water, optimization of refrigerated water use and flow, and use of a consolidated compressed air management system.[37]

Photo: Rohm and Haas' Knoxville, TN plant

14. Rome, Georgia - U.S. Biofuels

U.S. Biofuels makes biodiesel from poultry grease. The company was started in 2003 as a spin-off from the owners' chemical business. The company is in the process of expanding its operations to increase production from 300,000 gallons a month to 800,000 gallons.[38]

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[37] http://www.nrel.gov/docs/fy04osti/34705.pdf

[38] 6/20/2006, The Atlanta Journal-Constitution, "Biodiesel, Ethanol Hold Big Promise."

Chapter VI. Energy Intensity in Appalachia

Understanding energy use patterns at the local level is a critical part of evaluating policy innovations directed at altering energy use among individuals and firms. Unfortunately, local energy use patterns must be estimated from more aggregated state level data. To do so, the study team estimated several measures of state level energy use in a series of models which account for the dominant determinants of energy use.

Two of the most common measures of energy intensity are total energy consumption per capita and per unit of personal income. The study team estimated these rates as a function of personal income, average electricity prices, manufacturing's share of employment income, average annual temperature spreads and the proportion of a county living in urban areas. A statistical technique was also employed that permitted the capture of unobserved variables to be accounted for in our model. The model was tested on a panel of the lower 48 U.S. states from 2000 to 2004.

National and state-level energy intensity is shown in Table 6.1 below. Energy consumption is calculated in millions of British thermal units (mmbtu) per person (capita) and per unit of personal income ($1000). Five of the Appalachian states have lower than average state-wide energy use per capita. These states are more urban than the other eight states and energy use is undoubtedly weighted toward the urban areas which are not in the Appalachian region. Eight of the states have above-average energy use per capita.

Table 6.1: State and National Energy Intensity

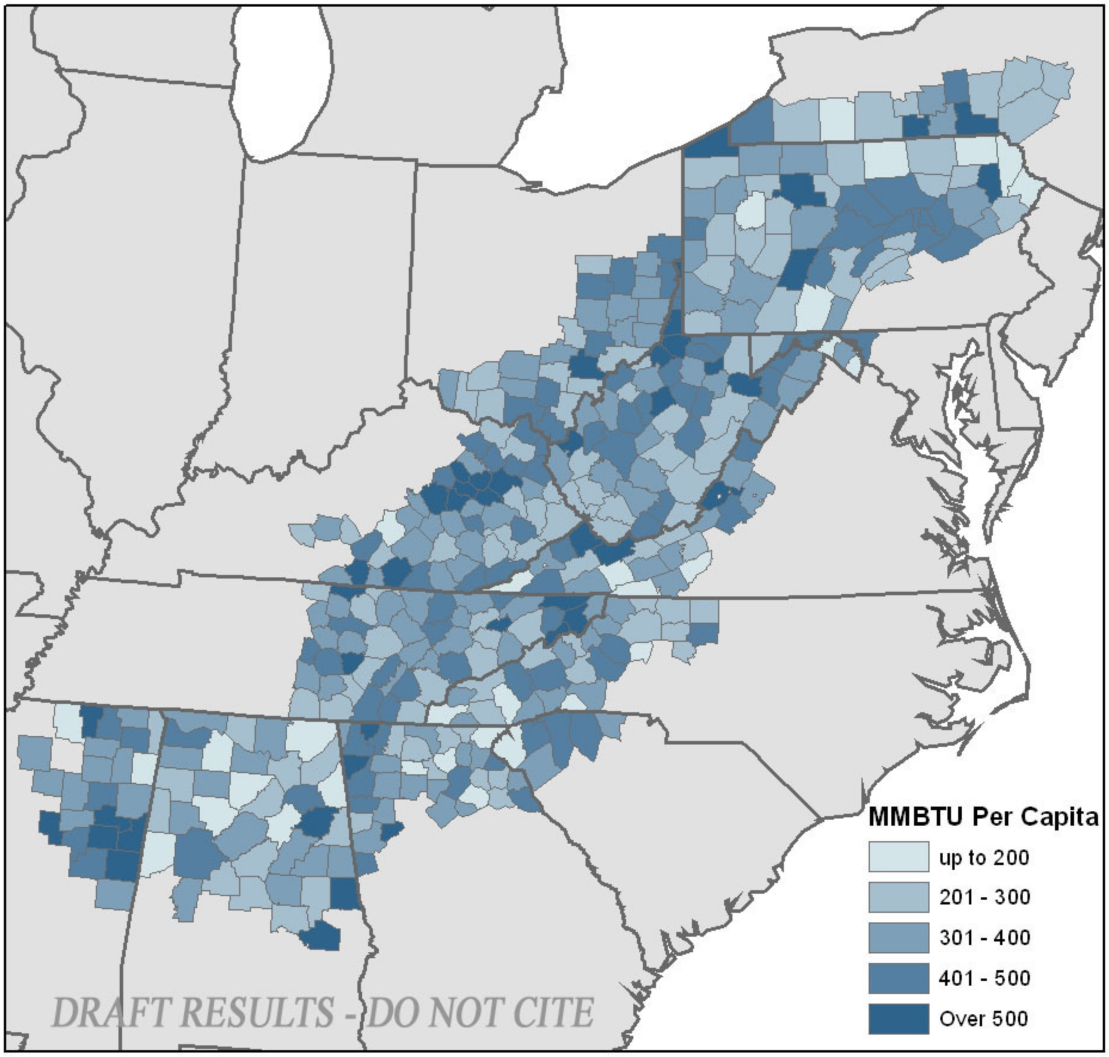
STATE	MMbtu/Capita	Mmbtu/$1000 Personal Income
New York	218	5.6
Maryland	268	6.4
Pennsylvania	319	9.5
North Carolina	322	10.3
Virginia	327	8.6
Ohio	351	11.2
Georgia	352	10.8
Tennessee	386	12.5
South Carolina	386	13.6
Mississippi	412	16.5
West Virginia	421	16.3
Alabama	437	15.5
Kentucky	465	16.6
United States	**338**	**11.0**

1. Energy Consumption Per Capita

State-wide statistical results were applied to county-specific data within the Appalachian region to estimate county-level energy intensity. Figure 6.1 presents estimated per capita energy consumption. These results show broad dispersion in per capita energy use, with manufacturing and population density having important effects. The overall region is very close to the national average per capita energy use. However, this is dominated by energy use trends in the heavily urban states of New York and Maryland. As shown above, most states have above-average consumption rates. This is likely due to high rates of electrification in some states, which may increase overall energy use, and a somewhat elevated share of manufacturing; the ARC counties account for about 26 percent of manufacturing income in the ARC states, but only 24.5 percent of the population.

At the county level, estimates of energy use per capita can are strongly influenced by the relative proportion of energy-intensive manufacturing to population. A sparsely populated county with a heavy industry present will have high per capita energy consumption. Conversely, urban counties with modest manufacturing presence may have low to average rates of energy consumption due to the more efficient residential use of energy in densely populated areas. County level energy intensity estimates are shown in Appendix C.

Figure 6.1: Estimated County-Level Per Capita Energy Intensity in Appalachia

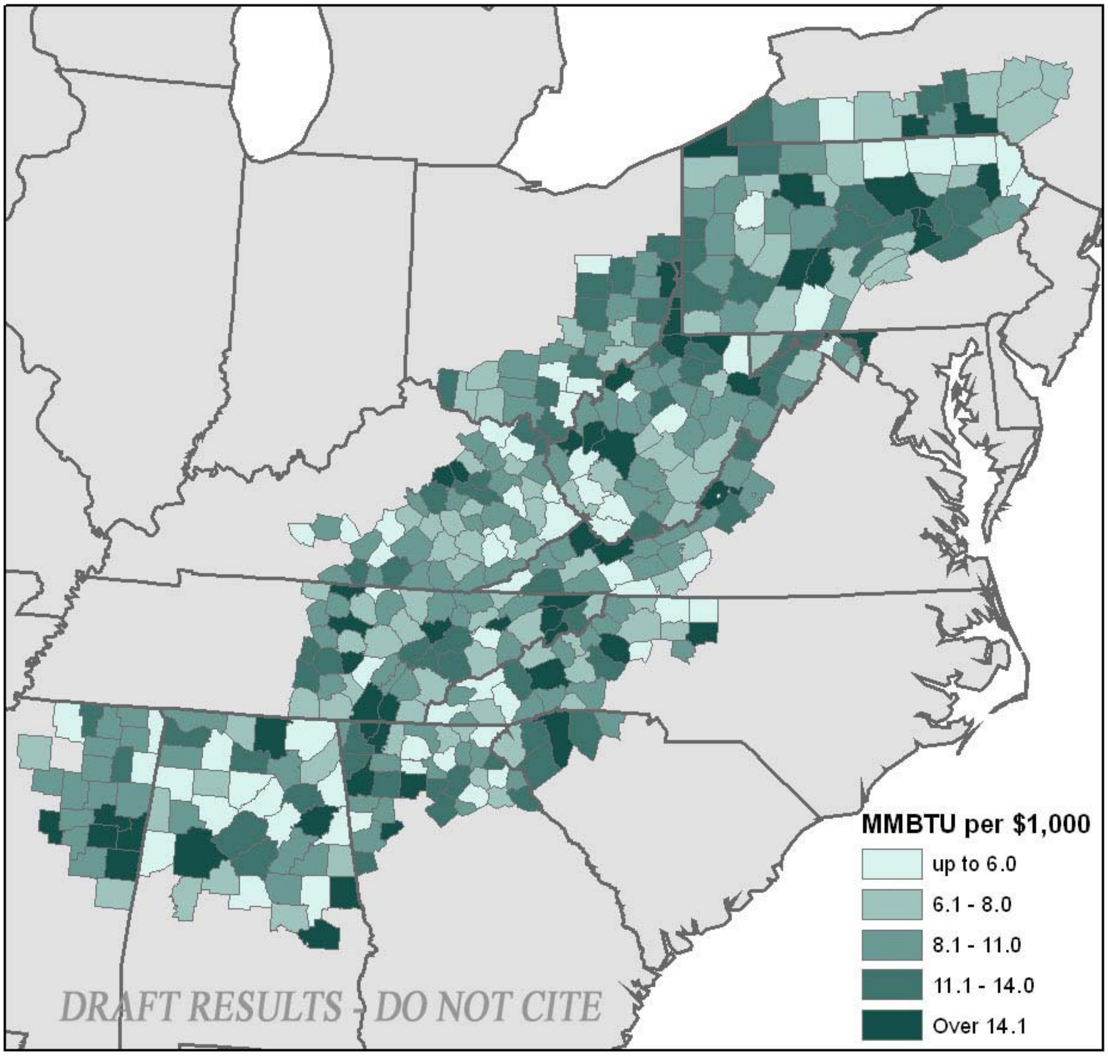


2. Energy Consumption Per Unit of Personal Income

Estimates of total energy use per dollar of personal income are shown in Figure 6.2. This is a county level measure of the energy intensity per dollar of economic activity. Again, the findings show that total energy use per dollar of personal income is heavily affected by industrial use and population density.

This measure of energy intensity also varies considerably by county. Economically distressed and at-risk counties with low personal income and little manufacturing will show below average consumption per unit of income, while those same counties with a single heavy manufacturing facility may be above-average consumers due to the dominance of that facility and the sparse population.

Figure 6.2: Estimated County-Level Economic Energy Intensity in Appalachia



3. Energy Demand Price Response

The responsiveness of residents and businesses to energy prices in another important policy consideration. In an effort to understand how policy innovations may alter use of energy, the price elasticity of demand for electricity for residential, commercial and industrial consumers in the Appalachian states was estimated by comparing price and demand trends from 2000 through 2004. The price elasticity of demand is formally the percentage change in quantity demanded when there is a one percent change in the price. These types of estimates are the stock in trade of economic analysis for more than a century. The results shown in Table 6.2 show that consumers of electricity are not very price responsive.

Table 6.2: Price Elasticity of Demand for Electricity in Appalachia

Residential Users	-0.15
Commercial Users	-0.17
Industrial Users	-0.55

The results of this estimate reaffirm a familiar belief among economists regarding price responsiveness of firms and consumers towards electricity use. In the short run electricity users are fairly price insensitive, and that this is especially true for residential and commercial users. These users are not likely to trade in appliances just because energy prices have increased. This is intuitively appealing since residential users tend to spend a small proportion of their total incomes on electricity, thus price fluctuations tend not to cause large changes in consumption. Further, since prices are dependent on factors that are local, both input costs and public utility pricing policies, they tend to change infrequently. This same argument is also true for commercial users, whose electricity costs are a relatively small share of their total production costs. In these cases, the capital costs of adopting new technologies may not be covered by the energy savings until the very long run.

Industrial users, who may bear very high energy costs, tend to be more price responsive than commercial users, and this may influence firm location decisions. This is especially true since industrial users are somewhat more flexible in their location decisions, as their sales are less tied to proximal population centers.

The policy insight garnered from this evidence is useful. For example, fiscal efforts to alter the effective price of electricity will have far more modest impacts on residential users than on industrial users. Policies to encourage installation of energy efficient or new technologies will not have very positive effects unless accompanied by heavy subsidization and education. On the other hand, energy audits which demonstrate how energy can be saved in industrial processes have positive results, as indicated elsewhere in the report.

4. Summary

Appalachian energy intensity is somewhat higher than in other areas of the country. Price, temperature variation, manufacturing share of employment and the degree of urban residences all matter in formulating both energy intensity and overall use. Appalachian residents and businesses are, like their counterparts in other regions, relatively unresponsive to electricity price changes in the short run. This thus provides some evidence of the magnitude of policy changes needed to alter short run use of energy.

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Appendix B: Wal-Mart and Alternative Fueled Vehicles – The Role of the Private Sector

Public sector efforts to spur alternative fuel use will necessarily be limited to the fiscal and regulatory instruments wielded by governments. Ultimately, these efforts will lead to changes in the private sector that are consistent with profit maximizing efforts by firms. One clear example is in the evolution of alternative fueled vehicle (AFV) adoption by consumers.

In 2005, the Center for Business and Economic Research evaluated the economic alternatives related to location of a FutureGen facility in which AFVs were examined. This study performed a detailed analysis of the role incomes, population concentration, gasoline and alternative fuel prices, state and federal gasoline taxes and state tax incentives played on adoption rates of AFVs. Among the policy relevant findings were that state and federal gasoline tax rates and state tax incentives for AFVs played an important role in the adoption of the new technology. However, even with extensive tax incentives, per capita rates of AFV usage are quite low. For example, while the study found that extending or strengthening these incentives would, in some instances, double the AFV usage rates, this translated into perhaps a few hundred to at most a few thousand additional vehicles in most states.

The authors attribute this disappointing result to the widespread absence of refueling facilities, both in Appalachia and nationwide. Thus the absence of an AFV fueling network may well then dampen the effectiveness of public policy. Happily, a recent announcement by Wal-Mart, that it is considering locating AFV fueling stations at many of its stores potentially changes dramatically the network availability of AFV fueling stations. To illustrate this, compare the two accompanying figures.

Figure B.1 employs data from the Energy Information Administration showing AFV fueling stations currently located in Appalachia. The relative paucity of stations and their clustering in urban areas clearly presents the problem. Figure B.2 illustrates the Wal-Mart and Super Center locations in Appalachia. The introduction of AFV fueling facilities in even 50 percent of these locations would dramatically extend the network of AFV fuel. This extension would, at the very least, better enable public policy efforts to promote alternative fuel use in the region.

Figure B.1: Location of Current Alternative Fuel Stations in Appalachia

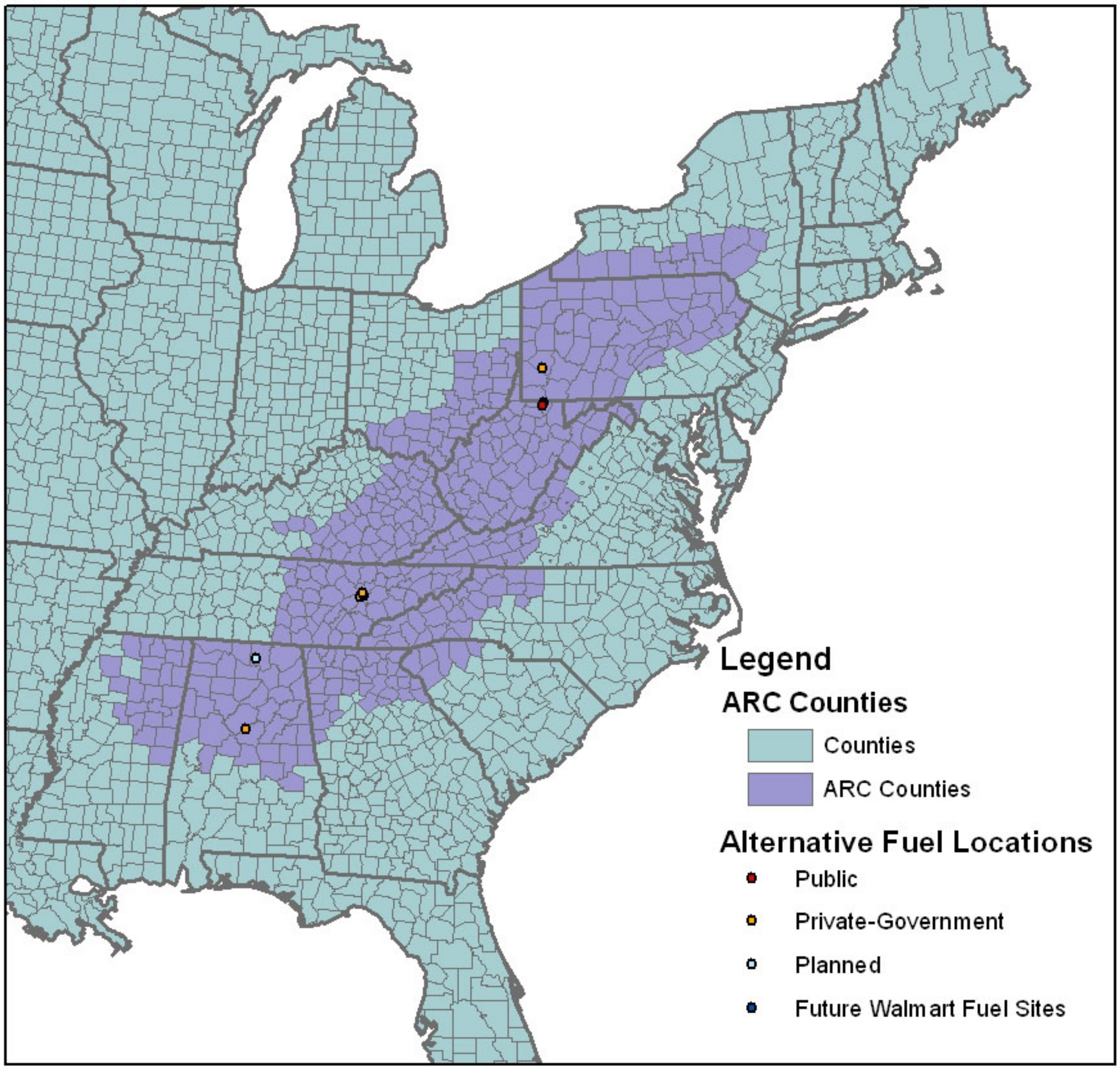
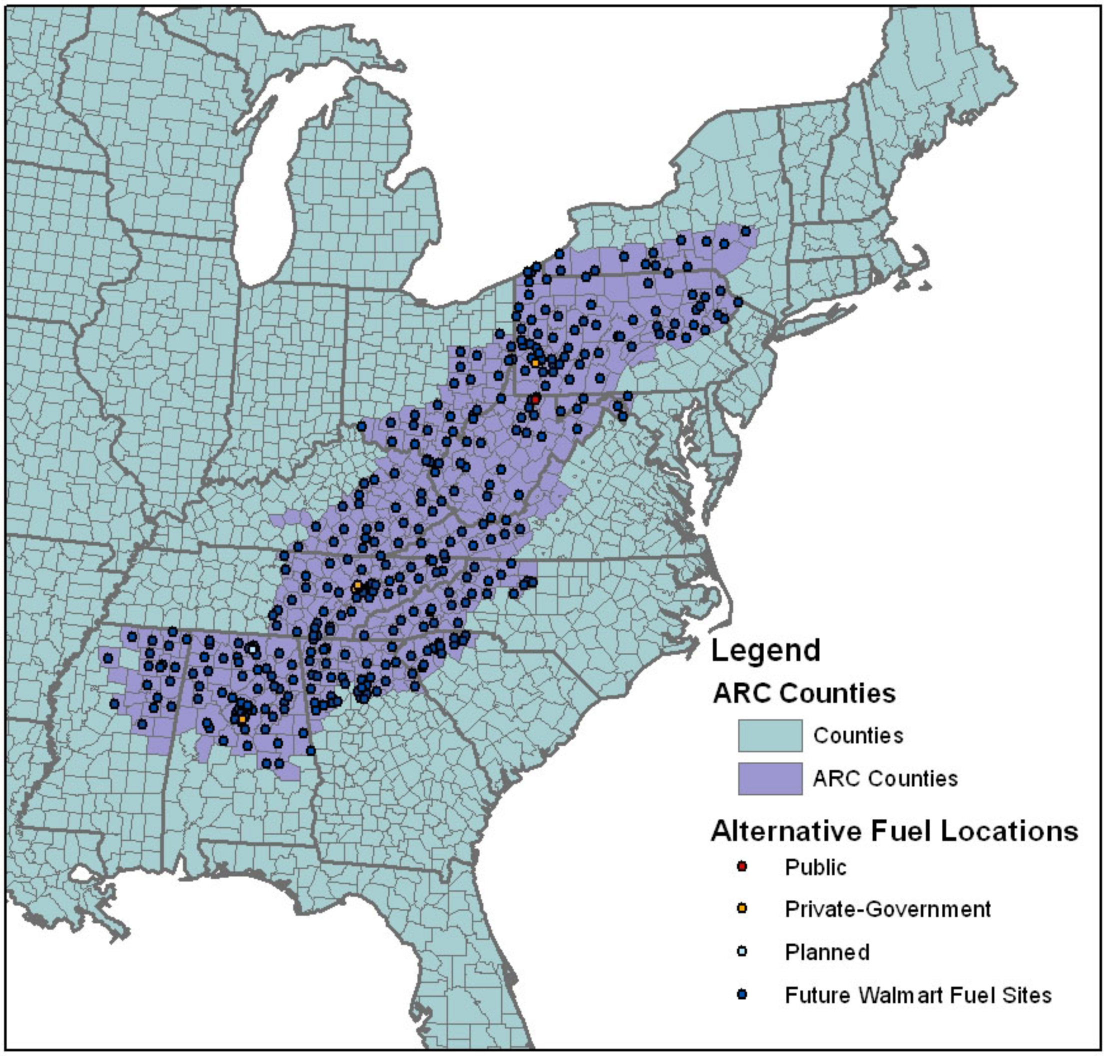


Figure B.2: Location of Potential Wal-Mart Alternative Fuel Stations in Appalachia



Appendix C: County vs. State Demographics

County vs. State - Alabama						
	Per capita income in 1999 (dollars)	% in Poverty	Total Population	Population Density	Median Age	Taxes per-capita
Alabama	**18,189**	**16.10%**	**4,447,100**	**33.8**	**35.8**	**1,550.99**
Counties:						
Bibb	14,105	20.6%	20,826	33.4	34.7	
Blount	16,325	11.7%	51,024	79.0	36.4	
Calhoun	17,367	16.1%	112,249	184.5	37.2	
Chambers	15,147	17.0%	36,583	61.3	37.7	
Cherokee	15,543	15.6%	23,988	43.4	40	
Chilton	15,303	15.7%	39,593	57.1	35.9	
Clay	13,785	17.1%	14,254	23.6	38.7	
Cleburne	14,762	13.9%	14,123	25.2	37.5	
Colbert	17,533	14.0%	54,984	92.5	38.7	
Coosa	14,875	14.9%	12,202	18.7	37.7	
Cullman	16,922	13.0%	77,483	104.9	37.5	
DeKalb	15,818	15.4%	64,452	82.9	36.3	
Elmore	17,650	10.2%	65,874	106.0	35.3	
Etowah	16,783	15.7%	103,459	193.4	38.3	
Fayette	14,439	17.3%	18,495	29.5	39	
Franklin	14,814	18.9%	31,223	49.1	36.7	
Hale	12,661	26.9%	17,185	26.7	34.4	
Jackson	16,000	13.7%	53,926	50.0	37.6	
Jefferson	20,892	14.8%	662,047	595.0	36	
Lamar	14,435	16.1%	15,904	26.3	38.2	
Lauderdale	18,626	14.4%	87,966	131.4	37.6	
Lawrence	16,515	15.3%	34,803	50.2	35.9	
Limestone	17,782	12.3%	65,676	115.6	35.8	
Macon	13,714	32.8%	24,105	39.5	32	
Madison	23,091	10.5%	276,700	343.8	35.7	
Marion	15,321	15.6%	31,214	42.1	38.9	
Marshall	17,089	14.7%	82,231	145.0	36.9	
Morgan	19,223	12.3%	111,064	190.8	36.6	
Pickens	13,746	24.9%	20,949	23.8	36.9	
Randolph	14,147	17.7%	22,380	38.5	37.7	
St.Clair	17,960	12.1%	64,742	102.2	36.4	
Shelby	27,176	6.3%	143,293	180.3	34.9	
Talladega	15,704	17.6%	80,321	108.6	36.6	
Tallapoosa	16,909	16.6%	41,475	57.8	39.3	
Tuscaloosa	18,998	17.0%	164,875	124.5	31.9	
Walker	15,546	16.5%	70,713	89.0	38.3	
Winston	15,738	17.1%	24,843	40.4	38	

County vs. State - Georgia						
	Per capita income in 1999 (dollars)	% in Poverty	Total Population	Population Density	Median Age	Taxes per-capita
Georgia	**21,154**	**13.00%**	**8,186,453**	**141.4**	**33.4**	**1,633.84**
Counties:						
Banks	17,424	12.5%	14,422	61.7	35.2	
Barrow	18,350	8.3%	46,144	284.5	32.5	
Bartow	18,989	8.6%	76,019	165.5	33.7	
Carroll	17,656	13.7%	87,268	174.9	32.5	
Catoosa	18,009	9.4%	53,282	328.4	35.8	
Chattooga	14,508	14.3%	25,470	81.3	36.5	
Cherokee	24,871	5.3%	141,903	334.9	34	
Dade	16,127	9.7%	15,154	87.1	36.1	
Dawson	22,520	7.6%	15,999	75.8	36.2	
Douglas	21,172	7.8%	92,174	462.5	33.8	
Elbert	14,535	17.3%	20,511	55.6	37.2	
Fannin	16,269	12.4%	19,798	51.3	43.1	
Floyd	17,808	14.4%	90,565	176.5	35.7	
Forsyth	29,114	5.5%	98,407	435.8	34.6	
Franklin	15,767	13.9%	20,285	77.0	37.6	
Gilmer	17,147	12.5%	23,456	55.0	37.3	
Gordon	17,586	9.9%	44,104	124.0	34.1	
Gwinnett	25,006	5.7%	588,448	1,359.9	32.5	
Habersham	17,706	12.2%	35,902	129.1	36.4	
Hall	19,690	12.4%	139,277	353.8	32.2	
Haralson	15,823	15.5%	25,690	91.1	36.1	
Hart	16,714	14.8%	22,997	99.0	39.2	
Heard	15,132	13.6%	11,012	37.2	34.1	
Jackson	17,808	12.0%	41,589	121.5	34.6	
Lumpkin	18,062	13.2%	21,016	73.9	32.5	
Madison	16,998	11.6%	25,730	90.6	35.8	
Murray	16,230	12.7%	36,506	106.0	32.6	
Paulding	19,974	5.5%	81,678	260.6	31.2	
Pickens	19,774	9.2%	22,983	99.0	37.9	
Polk	15,617	15.5%	38,127	122.5	35.1	
Rabun	20,608	11.1%	15,050	40.6	42	
Stephens	15,529	15.1%	25,435	141.9	37.5	
Towns	18,221	11.8%	9,319	55.9	48.6	
Union	18,845	12.5%	17,289	53.6	44.8	
Walker	15,867	12.5%	61,053	136.7	37.1	
White	17,193	10.5%	19,944	82.6	38.3	
Whitfield	18,515	11.5%	83,525	288.0	33	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - Kentucky						
	Per capita income in 1999 (dollars)	**% in Poverty**	**Total Population**	**Population Density**	**Median Age**	**Taxes per-capita**
Kentucky	**18,093**	**15.80%**	**4,041,769**	**101.7**	**35.9**	**2,043.31**
Counties:						
Adair	14,931	24.0%	17,244	42.4	36.9	
Bath	15,326	21.9%	11,085	39.7	37.4	
Bell	11,526	31.1%	30,060	83.3	37	
Boyd	18,212	15.5%	49,752	310.6	39.7	
Breathitt	11,044	33.2%	16,100	32.5	35.9	
Carter	13,442	22.3%	26,889	65.5	35.8	
Casey	12,867	25.5%	15,447	34.7	37.8	
Clark	19,170	10.6%	33,144	130.3	36.8	
Clay	9,716	39.7%	24,556	52.1	34.6	
Clinton	13,286	25.8%	9,634	48.8	39	
Cumberland	12,643	23.8%	7,147	23.4	40.1	
Edmonson	14,480	18.4%	11,644	38.5	38	
Elliott	12,067	25.9%	6,748	28.8	37	
Estill	12,285	26.4%	15,307	60.3	36.7	
Fleming	14,214	18.6%	13,792	39.3	36.3	
Floyd	12,442	30.3%	42,441	107.6	36.7	
Garrard	16,915	14.7%	14,792	64.0	37.1	
Green	16,107	18.4%	11,518	39.9	40	
Greenup	17,137	14.1%	36,891	106.6	39.2	
Harlan	11,585	32.5%	33,202	71.1	37.8	
Hart	13,495	22.4%	17,445	41.9	36.9	
Jackson	10,711	30.2%	13,495	39.0	34.9	
Johnson	14,051	26.6%	23,445	89.6	37.4	
Knott	11,297	31.1%	17,649	50.1	35.9	
Knox	10,660	34.8%	31,795	82.0	35.3	
Laurel	14,165	21.3%	52,715	121.0	35.5	
Lawrence	12,008	30.7%	15,569	37.2	36.5	
Lee	13,325	30.4%	7,916	37.7	37.4	
Leslie	10,429	32.7%	12,401	30.7	36.4	
Letcher	11,984	27.1%	25,277	74.6	37.9	
Lewis	12,031	28.5%	14,092	29.1	35.9	
Lincoln	13,602	21.1%	23,361	69.5	36	
Madison	9,896	16.8%	17,080	160.8	34.2	
Magoffin	16,790	36.6%	70,872	43.1	30.7	
Martin	10,685	37.0%	13,332	54.5	34.3	
McCreary	10,650	32.2%	12,578	39.9	34.1	
Menifee	11,399	29.6%	6,556	32.2	36.3	
Monroe	14,365	23.4%	11,756	35.5	38.2	
Montgomery	16,701	15.2%	22,554	113.6	36	
Morgan	12,657	27.2%	13,948	36.6	35.8	
Owsley	10,742	45.4%	4,858	24.5	38.2	

Perry	12,224	29.1%	29,390	85.9	36.3	
Pike	14,005	23.4%	68,736	87.3	37.1	
Powell	13,060	23.5%	13,237	73.5	34.8	
Pulaski	15,352	19.1%	56,217	85.0	38.5	
Rockcastle	12,337	23.1%	16,582	52.2	36.3	
Rowan	13,888	21.3%	22,094	78.7	29.8	
Russell	13,183	24.3%	16,315	64.4	39.9	
Wayne	12,601	29.4%	19,923	43.4	36.6	
Whitley	12,777	26.4%	35,865	81.5	35.4	
Wolfe	10,321	35.9%	7,065	31.7	36.4	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - Maryland

	Per capita income in 1999 (dollars)	% in Poverty	Total Population	Population Density	Median Age	Taxes per-capita
Maryland	**25,614**	**8.50%**	**5,296,486**	**541.9**	**36**	**2,216.86**
Counties:						
Allegany	16,780	14.8%	74,930	176.1	39.1	
Garrett	16,219	13.3%	29,846	46.1	38.3	
Washington	20,062	9.5%	131,923	288.0	37.4	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - Mississippi						
	Per capita income in 1999 (dollars)	**% in Poverty**	**Total Population**	**Population Density**	**Median Age**	**Taxes per-capita**
Mississippi	**15,853**	**19.90%**	**2,844,658**	**60.6**	**33.8**	**1,766.54**
Counties:						
Alcorn	15,418	16.6%	34,558	86.4	37.6	
Benton	12,212	23.2%	8,026	19.7	35.6	
Calhoun	15,106	18.1%	15,069	25.7	37.4	
Chickasaw	13,279	20.0%	19,440	38.8	34.4	
Choctaw	13,474	24.7%	9,758	23.3	36.9	
Clay	14,512	23.5%	21,979	53.8	33.9	
Itawamba	14,956	14.0%	22,770	42.8	36.2	
Kemper	11,985	26.0%	10,453	13.6	35.2	
Lee	18,956	13.4%	75,755	168.5	34.6	
Lowndes	16,514	21.3%	61,586	122.6	32.7	
Marshall	14,028	21.9%	34,993	49.5	33.9	
Monroe	14,072	17.2%	38,014	49.7	35.7	
Montgomery	14,040	24.3%	12,189	30.0	37.3	
Noxubee	12,018	32.8%	12,548	18.1	32.3	
Oktibbeha	14,998	28.2%	42,902	93.7	24.8	
Panola	13,075	25.3%	34,274	50.1	33	
Pontotoc	15,658	13.8%	26,726	53.7	34.8	
Prentiss	14,131	16.5%	25,556	61.6	35	
Tippah	14,041	16.9%	20,826	45.5	35.9	
Tishomingo	15,395	14.1%	19,163	45.2	39.1	
Union	15,700	12.6%	25,362	61.0	35.6	
Webster	14,109	18.7%	10,294	24.4	37.3	
Winston	14,548	23.7%	20,160	33.2	36.3	
Yalobusha	14,953	21.8%	13,051	27.9	37.7	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - New York						
	Per capita income in 1999 (dollars)	% in Poverty	Total Population	Population Density	Median Age	Taxes per-capita
New York	**23,389**	**14.60%**	**18,976,457**	**401.9**	**35.9**	**2,376.77**
Counties:						
Allegany	14,975	15.5%	49,927	48.5	35	
Broome	19,168	12.8%	200,536	283.7	38.2	
Cattaraugus	15,959	13.7%	83,955	64.1	37.4	
Chautauqua	16,840	13.8%	139,750	131.6	37.9	
Chemung	18,264	13.0%	91,070	223.1	37.9	
Chenango	16,427	14.4%	51,401	57.5	38.4	
Cortland	16,622	15.5%	48,599	97.3	34.2	
Delaware	17,357	12.9%	48,055	33.2	41.4	
Schoharie	17,778	11.4%	31,582	50.8	38	
Schuyler	17,039	11.8%	19,224	58.5	38.8	
Steuben	18,197	13.2%	98,726	70.9	38.2	
Tioga	18,673	8.4%	51,784	99.8	38	
Tompkins	19,659	17.6%	96,501	202.7	28.6	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - North Carolina						
	Per capita income in 1999 (dollars)	**% in Poverty**	**Total Population**	**Population Density**	**Median Age**	**Taxes per-capita**
North Carolina	**20,307**	**12.30%**	**8,049,313**	**165.2**	**35.3**	**1,971.48**
Counties:						
Alexander	18,507	8.5%	33,603	129.2	36.6	
Alleghany	17,691	17.2%	10,677	45.5	43	
Ashe	16,429	13.5%	24,384	57.2	42.1	
Buncombe	20,384	11.4%	206,330	314.5	38.9	
Burke	17,397	10.7%	89,148	175.9	36.9	
Caldwell	17,353	10.7%	77,415	164.2	37.5	
Cherokee	15,814	15.3%	24,298	53.4	44	
Clay	18,221	11.4%	8,775	40.9	46.7	
Davie	21,359	8.6%	34,835	131.4	38.4	
Forsyth	23,023	11.0%	306,067	747.2	36	
Graham	14,237	19.5%	7,993	27.4	41.5	
Haywood	18,554	11.5%	54,033	97.6	42.3	
Henderson	21,110	9.7%	89,173	238.4	42.7	
Jackson	17,582	15.1%	33,121	67.5	36.2	
McDowell	16,109	11.6%	42,151	95.4	38	
Macon	18,642	12.6%	29,811	57.7	45.2	
Madison	16,076	15.4%	19,635	43.7	39.3	
Mitchell	15,933	13.8%	15,687	70.8	42	
Polk	19,804	10.1%	18,324	77.0	44.9	
Rutherford	16,270	13.9%	62,899	111.5	38.3	
Stokes	18,130	9.1%	44,711	99.0	37.2	
Swain	14,647	18.3%	12,968	24.6	38.8	
Transylvania	20,767	9.5%	29,334	77.5	43.9	
Watauga	17,258	17.9%	42,695	136.6	29.9	
Wilkes	17,516	11.9%	65,632	86.7	38.5	
Yadkin	18,576	10.0%	36,348	108.3	37.6	
Yancey	16,335	15.8%	17,774	56.9	41.9	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - Ohio						
	Per capita income in 1999 (dollars)	% in Poverty	Total Population	Population Density	Median Age	Taxes per-capita
Ohio	**21,003**	**10.60%**	**11,353,140**	**277.3**	**36.2**	**1,962.93**
Counties:						
Adams	14,515	17.4%	27,330	46.8	36.3	
Athens	14,171	27.4%	62,223	122.8	25.7	
Belmont	16,221	14.6%	70,226	130.7	40.9	
Brown	17,100	11.6%	42,285	86.0	35.4	
Carroll	16,701	11.4%	28,836	73.1	38.8	
Clermont	22,370	7.1%	177,977	393.8	34.8	
Columbiana	16,655	11.5%	112,075	210.5	38.5	
Coshocton	16,364	9.1%	36,655	65.0	37.8	
Gallia	15,183	18.1%	31,069	66.3	37.4	
Guernsey	15,542	16.0%	40,792	78.2	37.7	
Harrison	16,479	13.3%	15,856	39.3	41.1	
Highland	16,521	11.8%	40,875	73.9	36.1	
Hocking	16,095	13.5%	28,241	66.8	37.7	
Holmes	14,197	12.9%	38,943	92.1	28	
Jackson	14,789	16.5%	32,641	77.7	36.3	
Jefferson	16,476	15.1%	73,894	180.4	41.6	
Lawrence	14,678	18.9%	62,319	137.0	37.6	
Meigs	13,848	19.8%	23,072	53.7	38.6	
Monroe	15,096	13.9%	15,180	33.3	40.8	
Morgan	13,967	18.4%	14,897	35.7	38.9	
Muskingum	17,533	12.9%	84,585	127.3	36.5	
Noble	14,100	11.4%	14,058	35.2	35.5	
Perry	15,674	11.8%	34,078	83.2	35	
Pike	16,093	18.6%	27,695	62.7	35.3	
Ross	17,569	12.0%	73,345	106.5	36.9	
Scioto	15,408	19.3%	79,195	129.3	36.7	
Tuscarawas	17,276	9.4%	90,914	160.2	37.9	
Vinton	13,731	20.0%	12,806	30.9	35.5	
Washington	18,082	11.4%	63,251	99.6	39.1	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - Pennsylvania						
	Per capita income in 1999 (dollars)	% in Poverty	Total Population	Population Density	Median Age	Taxes per-capita
Pennsylvania	**20,880**	**11.00%**	**12,281,054**	**274.0**	**38**	**2,045.09**
Counties:						
Allegheny	22,491	11.2%	1,281,666	1,755.3	39.6	
Armstrong	15,709	11.7%	72,392	110.7	40.4	
Beaver	18,402	9.4%	181,412	417.8	40.7	
Bedford	16,316	10.3%	49,984	49.3	39.5	
Blair	16,743	12.6%	129,144	245.6	39.5	
Bradford	17,148	11.8%	62,761	54.5	38.9	
Butler	20,794	9.1%	174,083	220.8	37.6	
Cambria	16,058	12.5%	152,598	221.8	41.2	
Cameron	15,968	9.4%	5,974	15.0	41.3	
Carbon	17,064	9.5%	58,802	154.3	40.6	
Centre	18,020	18.8%	135,758	122.6	28.7	
Clarion	15,243	15.4%	41,765	69.3	36.3	
Clearfield	16,010	12.5%	83,382	72.7	39.3	
Clinton	15,750	14.2%	37,914	42.6	37.8	
Columbia	16,973	13.1%	64,151	132.1	37.5	
Crawford	16,870	12.8%	90,366	89.2	38.1	
Elk	18,174	7.0%	35,112	42.4	39.4	
Erie	17,932	12.0%	280,843	350.2	36.2	
Fayette	15,274	18.0%	148,644	188.1	40.2	
Forest	14,341	16.4%	4,946	11.6	44.2	
Fulton	16,409	10.8%	14,261	32.6	38.2	
Greene	14,959	15.9%	40,672	70.6	38.2	
Huntingdon	15,379	11.3%	45,586	52.2	37.7	
Indiana	15,312	17.3%	89,605	108.1	36.2	
Jefferson	16,186	11.8%	45,932	70.1	39.8	
Juniata	16,142	9.5%	22,821	58.3	37.7	
Lackawanna	18,710	10.6%	213,295	465.1	40.3	
Lawrence	16,835	12.1%	94,643	262.6	40.5	
Luzerne	18,228	11.1%	319,250	358.4	40.8	
Lycoming	17,224	11.5%	120,044	97.2	38.4	
McKean	16,777	13.1%	45,936	46.8	38.7	
Mercer	17,636	11.5%	120,293	179.1	39.6	
Mifflin	15,553	12.5%	46,486	112.9	38.8	
Monroe	20,011	9.0%	138,687	227.9	37.2	
Montour	19,302	8.7%	18,236	139.5	39.8	
Northumberland	16,489	11.9%	94,556	205.6	40.8	
Perry	18,551	7.7%	43,602	78.8	37.5	
Pike	20,315	6.9%	46,302	84.7	39.6	
Potter	16,070	12.7%	18,080	16.7	39.1	
Schuylkill	17,230	9.5%	150,336	193.1	40.9	
Snyder	16,756	9.9%	37,546	113.4	36.7	

Somerset	15,178	11.8%	80,023	74.5	40.2	
Sullivan	16,438	14.5%	6,556	14.6	43	
Susquehanna	16,435	12.3%	42,238	51.3	39.5	
Tioga	15,549	13.5%	41,373	36.5	38.5	
Union	17,918	8.8%	41,624	131.4	35.8	
Venango	16,252	13.4%	57,565	85.3	40.2	
Warren	17,862	9.9%	43,863	49.6	40.5	
Washington	19,935	9.8%	202,897	236.7	40.8	
Wayne	16,977	11.3%	47,722	65.4	40.8	
Westmoreland	19,674	8.6%	369,993	360.8	41.3	
Wyoming	17,452	10.2%	28,080	70.7	37.8	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - South Carolina						
	Per capita income in 1999 (dollars)	**% in Poverty**	**Total Population**	**Population Density**	**Median Age**	**Taxes per-capita**
South Carolina	**18,795**	**14.10%**	**4,012,012**	**133.2**	**35.4**	**1,620.67**
Counties:						
Anderson	18,365	12.0%	165,740	230.8	37.3	
Cherokee	16,421	13.9%	52,537	133.8	35.3	
Greenville	22,081	10.5%	379,616	480.5	35.5	
Oconee	18,965	10.8%	66,215	105.9	39.5	
Pickens	17,434	13.7%	110,757	222.9	32.7	
Spartanburg	18,738	12.3%	253,791	313.0	36.1	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - Tennessee						
	Per capita income in 1999 (dollars)	**% in Poverty**	**Total Population**	**Population Density**	**Median Age**	**Taxes per-capita**
Tennessee	**19,393**	**13.50%**	**5,689,283**	**138.0**	**35.9**	**1,617.03**
Counties:						
Anderson	19,009	13.1%	71,330	211.3	39.9	
Bledsoe	13,889	18.1%	12,367	30.4	37.4	
Blount	19,416	9.7%	105,823	189.5	38.4	
Bradley	18,108	12.2%	87,965	267.6	35.5	
Campbell	13,301	22.8%	39,854	83.0	38.3	
Cannon	16,405	12.8%	12,826	48.3	36.8	
Carter	14,678	16.9%	56,742	166.4	38.5	
Claiborne	13,032	22.6%	29,862	68.8	37.4	
Clay	13,320	19.1%	7,976	33.8	39.9	
Cocke	13,881	22.5%	33,565	77.3	38.6	
Coffee	18,137	14.3%	48,014	112.0	37.5	
Cumberland	16,808	14.7%	46,802	68.7	42.5	
DeKalb	17,217	17.0%	17,423	57.2	37.7	
Fentress	12,999	23.1%	16,625	33.3	38	
Franklin	17,987	13.2%	39,270	70.8	38.1	
Grainger	14,505	18.7%	20,659	73.7	37.7	
Greene	15,746	14.5%	62,909	101.2	38.9	
Grundy	12,039	25.8%	14,332	39.7	36.6	
Hamblen	17,743	14.4%	58,128	361.0	37.1	
Hamilton	21,593	12.1%	307,896	567.6	37.4	
Hancock	11,986	29.4%	6,786	30.5	39.2	
Hawkins	16,073	15.8%	53,563	110.1	37.8	
Jackson	15,020	18.1%	10,984	35.6	39.8	
Jefferson	16,841	13.4%	44,294	161.8	36.5	
Johnson	13,388	22.6%	17,499	58.6	40	
Knox	21,875	12.6%	382,032	751.3	36	
Loudon	21,061	10.0%	39,086	170.8	41	
McMinn	16,725	14.5%	49,015	113.9	37.9	
Macon	15,286	15.1%	20,386	66.4	35.5	
Marion	16,419	14.1%	27,776	55.7	38.2	
Meigs	14,551	18.3%	11,086	56.9	36.7	
Monroe	14,951	15.5%	38,961	61.4	36.8	
Morgan	12,925	16.0%	19,757	37.8	36.5	
Overton	13,910	16.0%	20,118	46.4	38.8	
Pickett	14,681	15.6%	4,945	30.4	41.6	
Polk	16,025	13.0%	16,050	36.9	38.6	
Putnam	16,927	16.4%	62,315	155.4	34.4	
Rhea	15,672	14.7%	28,400	89.9	37.2	
Roane	18,456	13.9%	51,910	143.8	40.7	
Scott	12,927	20.2%	21,127	39.7	34.7	
Sequatchie	16,468	16.5%	11,370	42.8	36.7	

Sevier	18,064	10.7%	71,170	120.2	38.1	
Smith	17,473	12.2%	17,712	56.3	36.8	
Sullivan	19,202	12.9%	153,048	370.6	40.1	
Unicoi	15,612	13.1%	17,667	94.9	41.5	
Union	13,375	19.6%	17,808	79.7	35.8	
Van Buren	17,497	15.2%	5,508	20.1	38.7	
Warren	15,759	16.6%	38,276	88.5	36.6	
Washington	19,085	13.9%	107,198	328.5	37.1	
White	14,791	14.3%	23,102	61.3	38.8	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - Virginia						
	Per capita income in 1999 (dollars)	**% in Poverty**	**Total Population**	**Population Density**	**Median Age**	**Taxes per-capita**
Virginia	**23,975**	**9.60%**	**7,078,515**	**178.8**	**35.7**	**1,902.56**
Counties:						
Alleghany	19,635	7.1%	12,926	29.1	41.1	
Bath	23,092	7.8%	5,048	9.5	41.8	
Bland	17,744	12.4%	6,871	19.2	40.3	
Botetourt	22,218	5.2%	30,496	56.2	40.7	
Buchanan	12,788	23.2%	26,978	53.5	38.8	
Carroll	16,475	12.5%	29,245	61.4	40.7	
Craig	17,322	10.3%	5,091	15.4	39.6	
Dickenson	12,822	21.3%	16,395	49.4	39.7	
Floyd	16,345	11.7%	13,874	36.4	40.5	
Giles	18,396	9.5%	16,657	46.6	40.2	
Grayson	16,768	13.6%	17,917	40.5	40.5	
Highland	15,976	12.6%	2,536	6.1	46	
Lee	13,625	23.9%	23,589	54.0	39.7	
Montgomery	17,077	23.2%	83,629	215.4	25.9	
Pulaski	18,973	13.1%	35,127	109.6	40.3	
Rockbridge	18,356	9.6%	20,808	34.7	40.4	
Russell	14,863	16.3%	30,308	63.9	38.7	
Scott	15,073	16.8%	23,403	43.6	41.4	
Smyth	16,105	13.3%	33,081	73.2	40	
Tazewell	15,282	15.3%	44,598	85.8	40.7	
Washington	18,350	10.9%	51,103	90.8	40.3	
Wise	14,271	20.0%	40,123	99.3	37.8	
Wythe	17,639	11.0%	27,599	59.6	39.4	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

County vs. State - West Virginia						
	Per capita income in 1999 (dollars)	% in Poverty	Total Population	Population Density	Median Age	Taxes per-capita
West Virginia	**16,477**	**17.90%**	**1,808,344**	**75.1**	**38.9**	**2,067.85**
Counties:						
Barbour	12,440	22.6%	15,557	45.7	38.7	
Berkeley	17,982	11.5%	75,905	236.4	35.8	
Boone	14,453	22.0%	25,535	50.8	38.8	
Braxton	13,349	22.0%	14,702	28.6	39.6	
Brooke	17,131	11.7%	25,447	286.4	41.2	
Cabell	17,638	19.2%	96,784	343.7	37.5	
Calhoun	11,491	25.1%	7,582	27.0	41.3	
Clay	12,021	27.5%	10,330	30.2	36.8	
Doddridge	13,507	19.8%	7,403	23.1	38.7	
Fayette	13,809	21.7%	47,579	71.7	39.6	
Gilmer	12,498	25.9%	7,160	21.1	36.8	
Grant	15,696	16.3%	11,299	23.7	39.3	
Greenbrier	16,247	18.2%	34,453	33.7	41.6	
Hampshire	14,851	16.3%	20,203	31.5	38.5	
Hancock	17,724	11.1%	32,667	394.4	41.7	
Hardy	15,859	13.1%	12,669	21.7	38.9	
Harrison	16,810	17.2%	68,652	165.0	39.2	
Jackson	16,205	15.2%	28,000	60.1	38.8	
Jefferson	20,441	10.3%	42,190	201.4	36.8	
Kanawha	20,354	14.4%	200,073	221.5	40.2	
Lewis	13,933	19.9%	16,919	44.3	40.1	
Lincoln	13,073	27.9%	22,108	50.5	37.4	
Logan	14,102	24.1%	37,710	83.0	39.3	
McDowell	10,174	37.7%	27,329	51.1	40.5	
Marion	16,246	16.3%	56,598	182.8	39.9	
Marshall	16,472	16.6%	35,519	115.7	40.4	
Mason	14,804	19.9%	25,957	60.1	39.7	
Mercer	15,564	19.7%	62,980	149.8	40.2	
Mineral	15,384	14.7%	27,078	82.6	39.1	
Mingo	12,445	29.7%	28,253	66.9	37.2	
Monongalia	17,106	22.8%	81,866	226.7	30.4	
Monroe	17,435	16.2%	14,583	30.8	39.7	
Morgan	18,109	10.4%	14,943	65.3	40.7	
Nicholas	15,207	19.2%	26,562	41.0	39.4	
Ohio	17,734	15.8%	47,427	446.7	40.6	
Pendleton	15,805	11.4%	8,196	11.7	41.1	
Pleasants	16,920	13.7%	7,514	57.5	38.9	
Pocahontas	14,384	17.1%	9,131	9.7	41.9	
Preston	13,596	18.3%	29,334	45.2	39.1	
Putnam	20,471	9.3%	51,589	149.0	37.7	

Raleigh	16,233	18.5%	79,220	130.5	39.5	
Randolph	14,918	18.0%	28,262	27.2	38.8	
Ritchie	15,175	19.1%	10,343	22.8	39.9	
Roane	13,195	22.6%	15,446	31.9	39.5	
Summers	12,419	24.4%	12,999	36.0	43.4	
Taylor	13,681	20.3%	16,089	93.1	39.1	
Tucker	16,349	18.1%	7,321	17.5	42	
Tyler	15,216	16.6%	9,592	37.2	40.8	
Upshur	13,559	20.0%	23,404	66.0	37.4	
Wayne	14,906	19.6%	42,903	84.8	38.4	
Webster	12,284	31.8%	9,719	17.5	40.4	
Wetzel	16,818	19.8%	17,693	49.3	40.4	
Wirt	14,000	19.6%	5,873	25.2	37.9	
Wood	18,073	13.9%	87,986	239.6	39.3	
Wyoming	14,220	25.1%	25,708	51.3	40.1	

Source: U.S. Census Bureau: 2000 Census of Population and Housing

Appendix D: Estimated Energy Intensity by County in Appalachia

FIPS	County	State	mmbtu/capita	mmbtu/$1000
21165	Menifee	KY	725	13.7
28103	Noxubee	MS	702	15.6
1087	Macon	AL	673	14.2
28097	Montgomery	MS	671	16.5
21057	Cumberland	KY	647	13.5
47063	Hamblen	TN	642	19.3
28025	Clay	MS	640	16.2
13055	Chattooga	GA	636	14.0
21173	Montgomery	KY	609	15.7
47027	Clay	TN	608	14.2
36015	Chemung	NY	597	17.4
21237	Wolfe	KY	589	11.7
54091	Taylor	WV	589	13.7
28009	Benton	MS	584	11.8
42049	Erie	PA	583	17.8
28105	Oktibbeha	MS	582	15.6
47175	Van Buren	TN	575	15.3
51045	Craig	VA	575	16.7
54095	Tyler	WV	566	13.6
51933	Montgomery + Radford	VA	561	14.4
47019	Carter	TN	559	13.6
1017	Chambers	AL	559	14.3
47171	Unicoi	TN	555	15.9
21231	Wayne	KY	551	12.3
42069	Lackawanna	PA	549	18.8
13047	Catoosa	GA	545	15.7
54029	Hancock	WV	545	16.0
54093	Tucker	WV	544	14.5
54103	Wetzel	WV	541	14.9
39009	Athens	OH	540	13.2
54021	Gilmer	WV	536	12.9
21197	Powell	KY	531	11.8
51017	Bath	VA	529	18.1
36007	Broome	NY	528	16.5
28087	Lowndes	MS	526	14.6
13097	Douglas	GA	521	16.8
21175	Morgan	KY	520	9.5
1015	Calhoun	AL	517	15.7
47163	Sullivan	TN	516	16.8
42021	Cambria	PA	514	15.0
42047	Elk	PA	511	16.4
21065	Estill	KY	506	10.9
54051	Marshall	WV	505	14.3
54011	Cabell	WV	504	16.1
21151	Madison	KY	503	13.1
42119	Union	PA	500	13.8
54013	Calhoun	WV	499	10.2
42097	Northumberland	PA	497	14.4
24001	Allegany	MD	496	13.8
45045	Greenville	SC	493	17.7
13295	Walker	GA	491	13.1
36023	Cortland	NY	491	13.4
21069	Fleming	KY	489	10.5
39081	Jefferson	OH	488	14.2

Appendix D: Estimated Energy Intensity by County in Appalachia

FIPS	County	State	mmbtu/capita	mmbtu/$1000
13313	Whitfield	GA	487	16.3
42013	Blair	PA	484	14.8
42035	Clinton	PA	484	13.2
36013	Chautauqua	NY	480	12.9
37027	Caldwell	NC	479	14.3
54107	Wood	WV	479	15.1
47179	Washington	TN	478	14.9
54017	Doddridge	WV	477	10.1
47011	Bradley	TN	474	15.2
42107	Schuylkill	PA	474	14.0
13105	Elbert	GA	474	12.2
47141	Putnam	TN	473	14.2
21147	McCreary	KY	473	8.9
54009	Brooke	WV	471	13.6
21049	Clark	KY	470	15.5
1125	Tuscaloosa	AL	468	15.6
13149	Heard	GA	467	11.1
54023	Grant	WV	465	12.7
21089	Greenup	KY	464	13.0
42081	Lycoming	PA	463	14.5
13115	Floyd	GA	461	14.6
21189	Owsley	KY	460	10.0
21013	Bell	KY	460	9.8
37021	Buncombe	NC	460	15.0
1033	Colbert	AL	459	12.9
54061	Monongalia	WV	458	15.4
13257	Stephens	GA	458	12.6
47067	Hancock	TN	456	7.8
1055	Etowah	AL	456	13.3
39157	Tuscarawas	OH	455	13.0
54089	Summers	WV	454	9.6
39087	Lawrence	OH	453	11.5
28019	Choctaw	MS	452	9.1
54069	Ohio	WV	449	16.2
45077	Pickens	SC	449	12.5
28159	Winston	MS	449	10.6
42073	Lawrence	PA	449	13.2
54049	Marion	WV	448	13.6
39029	Columbiana	OH	446	12.3
45083	Spartanburg	SC	444	13.5
47065	Hamilton	TN	444	17.2
39079	Jackson	OH	442	11.1
51027	Buchanan	VA	442	11.5
51903	Alleghany + Covington	VA	436	12.6
42027	Centre	PA	435	13.5
47013	Campbell	TN	435	11.0
21095	Harlan	KY	434	9.2
47001	Anderson	TN	434	14.3
21119	Knott	KY	434	9.2
54039	Kanawha	WV	434	17.0
37023	Burke	NC	432	12.2
13139	Hall	GA	432	13.3
28017	Chickasaw	MS	431	10.4
24043	Washington	MD	430	14.5
21205	Rowan	KY	430	10.2

Appendix D: Estimated Energy Intensity by County in Appalachia

FIPS	County	State	mmbtu/capita	mmbtu/$1000
54097	Upshur	WV	429	10.2
47143	Rhea	TN	427	10.9
47009	Blount	TN	427	13.6
37067	Forsyth	NC	427	16.7
42037	Columbia	PA	424	13.2
54055	Mercer	WV	424	12.1
42087	Mifflin	PA	422	11.2
54057	Mineral	WV	418	11.1
47177	Warren	TN	417	11.6
54087	Roane	WV	416	9.2
39145	Scioto	OH	416	10.8
54041	Lewis	WV	416	10.8
21127	Lawrence	KY	414	8.4
21001	Adair	KY	413	9.4
54079	Putnam	WV	413	14.1
28117	Prentiss	MS	412	9.0
42093	Montour	PA	410	14.9
47015	Cannon	TN	408	12.4
39115	Morgan	OH	406	9.5
51155	Pulaski	VA	406	12.2
54101	Webster	WV	406	8.2
21063	Elliott	KY	403	7.1
37087	Haywood	NC	403	11.9
13233	Polk	GA	402	9.8
51071	Giles	VA	401	10.6
21019	Boyd	KY	401	12.9
39031	Coshocton	OH	401	11.2
28139	Tippah	MS	401	9.8
47107	McMinn	TN	401	10.7
21099	Hart	KY	399	8.1
39013	Belmont	OH	398	11.5
39119	Muskingum	OH	397	11.8
47173	Union	TN	396	8.4
42123	Warren	PA	396	11.6
28155	Webster	MS	395	8.7
51021	Bland	VA	394	9.5
36109	Tompkins	NY	393	12.3
45007	Anderson	SC	392	12.0
54033	Harrison	WV	392	13.0
21235	Whitley	KY	391	9.1
1089	Madison	AL	389	14.9
42129	Westmoreland	PA	388	13.5
39059	Guernsey	OH	388	10.2
13015	Bartow	GA	387	12.3
13311	White	GA	387	10.5
13111	Fannin	GA	387	10.3
28013	Calhoun	MS	387	10.7
13057	Cherokee	GA	385	14.2
21051	Clay	KY	384	7.0
28095	Monroe	MS	384	9.9
28003	Alcorn	MS	384	9.8
47041	DeKalb	TN	383	10.9
47031	Coffee	TN	383	12.8
21079	Garrard	KY	383	9.4
21025	Breathitt	KY	381	8.1

Appendix D: Estimated Energy Intensity by County in Appalachia

FIPS	County	State	mmbtu/capita	mmbtu/$1000
42007	Beaver	PA	381	12.0
28081	Lee	MS	380	12.5
47029	Cocke	TN	380	8.5
47145	Roane	TN	379	11.4
13223	Paulding	GA	378	10.9
21109	Jackson	KY	376	6.7
42051	Fayette	PA	376	11.0
42085	Mercer	PA	376	11.0
13083	Dade	GA	375	9.8
21203	Rockcastle	KY	373	7.8
54099	Wayne	WV	373	9.0
51173	Smyth	VA	372	9.8
21171	Monroe	KY	371	8.7
1057	Fayette	AL	370	9.3
51955	Wise + Norton	VA	370	9.4
47093	Knox	TN	370	13.7
1103	Morgan	AL	369	12.4
13147	Hart	GA	369	9.5
42121	Venango	PA	365	10.9
42125	Washington	PA	365	13.2
54035	Jackson	WV	365	9.3
42079	Luzerne	PA	364	12.2
39025	Clermont	OH	364	13.4
54085	Ritchie	WV	363	9.2
45021	Cherokee	SC	363	9.4
13135	Gwinnett	GA	362	13.3
28161	Yalobusha	MS	361	9.0
47091	Johnson	TN	361	7.3
54071	Pendleton	WV	361	9.8
54019	Fayette	WV	359	8.9
47049	Fentress	TN	359	9.0
37199	Yancey	NC	359	8.4
51185	Tazewell	VA	357	9.8
1077	Lauderdale	AL	356	10.2
37075	Graham	NC	354	9.1
54053	Mason	WV	354	8.4
47105	Loudon	TN	353	12.1
51953	Washington + Bristol	VA	353	10.8
28069	Kemper	MS	352	7.6
1121	Talladega	AL	352	10.3
1037	Coosa	AL	351	8.2
39131	Pike	OH	351	8.7
42057	Fulton	PA	350	10.7
47159	Smith	TN	349	9.6
47121	Meigs	TN	349	8.5
51051	Dickenson	VA	348	7.8
47061	Grundy	TN	348	8.4
54031	Hardy	WV	347	9.1
39121	Noble	OH	347	6.9
21121	Knox	KY	344	7.8
42025	Carbon	PA	343	10.9
47073	Hawkins	TN	343	9.0
47025	Claiborne	TN	343	8.5
42033	Clearfield	PA	342	9.7
37009	Ashe	NC	335	9.5

Appendix D: Estimated Energy Intensity by County in Appalachia

FIPS	County	State	mmbtu/capita	mmbtu/$1000
47151	Scott	TN	335	7.2
21053	Clinton	KY	335	8.1
13013	Barrow	GA	334	9.7
47185	White	TN	331	7.9
21129	Lee	KY	330	6.6
1027	Clay	AL	329	8.5
54015	Clay	WV	329	6.1
37175	Transylvania	NC	329	9.7
37089	Henderson	NC	328	11.0
1065	Hale	AL	328	7.3
54003	Berkeley	WV	328	10.6
39073	Hocking	OH	328	8.7
37043	Clay	NC	328	8.5
39111	Monroe	OH	327	8.4
54001	Barbour	WV	326	7.5
1059	Franklin	AL	326	8.7
28115	Pontotoc	MS	326	8.4
39067	Harrison	OH	325	8.5
13045	Carroll	GA	324	9.1
1111	Randolph	AL	324	8.0
28145	Union	MS	323	8.3
51945	Rockbridge, Buena Vista + Lexington	VA	321	9.8
39019	Carroll	OH	317	8.4
39141	Ross	OH	317	8.9
54081	Raleigh	WV	317	9.5
54005	Boone	WV	315	7.6
42083	McKean	PA	315	9.3
21115	Johnson	KY	314	7.5
37189	Watauga	NC	313	9.3
47087	Jackson	TN	311	8.4
21199	Pulaski	KY	310	8.6
51063	Floyd	VA	309	8.2
28107	Panola	MS	309	7.2
13129	Gordon	GA	308	8.8
1073	Jefferson	AL	308	12.8
13137	Habersham	GA	308	8.9
36107	Tioga	NY	306	8.9
21011	Bath	KY	306	7.0
13117	Forsyth	GA	305	11.8
54027	Hampshire	WV	304	7.2
37161	Rutherford	NC	303	8.2
37011	Avery	NC	303	8.4
1133	Winston	AL	303	7.6
47129	Morgan	TN	303	6.3
21137	Lincoln	KY	301	6.4
47153	Sequatchie	TN	300	7.7
36009	Cattaraugus	NY	299	8.7
13085	Dawson	GA	297	10.1
42089	Monroe	PA	295	9.2
42065	Jefferson	PA	295	8.3
1095	Marshall	AL	294	9.1
42019	Butler	PA	292	10.6
13213	Murray	GA	292	7.3
1117	Shelby	AL	291	12.5
1075	Lamar	AL	291	7.0

Appendix D: Estimated Energy Intensity by County in Appalachia

FIPS	County	State	mmbtu/capita	mmbtu/$1000
47133	Overton	TN	290	7.2
54083	Randolph	WV	284	8.1
47057	Grainger	TN	284	6.9
21125	Laurel	KY	282	6.8
42061	Huntingdon	PA	280	7.0
51197	Wythe	VA	280	7.4
47137	Pickett	TN	278	5.9
42053	Forest	PA	278	7.5
47139	Polk	TN	278	7.2
37115	Madison	NC	278	7.2
42059	Greene	PA	278	7.0
54059	Mingo	WV	277	6.8
36097	Schuyler	NY	276	7.6
54073	Pleasants	WV	275	8.7
54047	McDowell	WV	274	5.4
39127	Perry	OH	274	6.5
54105	Wirt	WV	273	5.7
39163	Vinton	OH	273	5.9
37059	Davie	NC	270	9.6
39001	Adams	OH	269	6.5
39105	Meigs	OH	266	6.0
54063	Monroe	WV	266	6.3
1007	Bibb	AL	266	6.2
21133	Letcher	KY	266	6.2
51091	Highland	VA	265	8.2
47123	Monroe	TN	264	6.5
54067	Nicholas	WV	263	6.6
13291	Union	GA	261	7.2
21071	Floyd	KY	261	6.4
37111	McDowell	NC	260	6.6
37005	Alleghany	NC	260	7.6
21087	Green	KY	259	5.6
37121	Mitchell	NC	259	6.2
39167	Washington	OH	259	7.7
42111	Somerset	PA	257	6.8
42109	Snyder	PA	256	8.0
47111	Macon	TN	256	6.6
47051	Franklin	TN	254	7.0
24023	Garrett	MD	253	7.5
37113	Macon	NC	253	7.2
39071	Highland	OH	253	6.8
51169	Scott	VA	253	6.2
42039	Crawford	PA	252	6.8
37193	Wilkes	NC	251	7.7
21153	Magoffin	KY	250	5.2
13281	Towns	GA	250	7.3
42063	Indiana	PA	250	7.4
21207	Russell	KY	249	5.7
36017	Chenango	NY	246	6.8
54025	Greenbrier	WV	246	7.0
54075	Pocahontas	WV	246	6.7
42005	Armstrong	PA	246	7.5
51023	Botetourt	VA	245	8.9
1051	Elmore	AL	245	7.3
54007	Braxton	WV	242	5.2

Appendix D: Estimated Energy Intensity by County in Appalachia

FIPS	County	State	mmbtu/capita	mmbtu/$1000
42105	Potter	PA	240	7.0
21135	Lewis	KY	239	4.5
54043	Lincoln	WV	236	5.0
47035	Cumberland	TN	236	6.6
21061	Edmonson	KY	236	4.8
13195	Madison	GA	235	6.8
36095	Schoharie	NY	235	6.8
36101	Steuben	NY	233	7.5
47115	Marion	TN	233	6.3
37197	Yadkin	NC	233	6.7
42113	Sullivan	PA	233	6.5
42131	Wyoming	PA	231	6.5
39075	Holmes	OH	230	5.5
21159	Martin	KY	230	5.1
1083	Limestone	AL	229	7.0
21043	Carter	KY	227	5.0
42067	Juniata	PA	227	6.8
36025	Delaware	NY	227	6.4
1021	Chilton	AL	227	5.9
39015	Brown	OH	226	6.5
54077	Preston	WV	221	5.6
36077	Otsego	NY	218	6.2
13123	Gilmer	GA	218	5.8
1029	Cleburne	AL	217	5.5
1049	DeKalb	AL	214	6.1
54045	Logan	WV	214	5.9
42023	Cameron	PA	214	6.1
42003	Allegheny	PA	213	9.6
1009	Blount	AL	211	5.6
21193	Perry	KY	211	5.5
13143	Haralson	GA	210	5.6
37169	Stokes	NC	209	5.9
21195	Pike	KY	209	5.3
37173	Swain	NC	208	5.1
13119	Franklin	GA	208	6.0
42015	Bradford	PA	208	5.8
21131	Leslie	KY	207	4.5
54109	Wyoming	WV	206	4.8
37171	Surry	NC	206	5.9
47089	Jefferson	TN	206	5.4
1123	Tallapoosa	AL	205	5.6
47007	Bledsoe	TN	205	5.0
1093	Marion	AL	204	5.2
13011	Banks	GA	203	6.1
42099	Perry	PA	203	6.4
47059	Greene	TN	202	6.8
28141	Tishomingo	MS	201	4.6
47155	Sevier	TN	201	6.4
39053	Gallia	OH	201	5.9
37149	Polk	NC	200	7.5
1019	Cherokee	AL	200	5.2
13241	Rabun	GA	197	5.6
21045	Casey	KY	196	4.2
1079	Lawrence	AL	196	5.4
1071	Jackson	AL	195	5.2

Appendix D: Estimated Energy Intensity by County in Appalachia

FIPS	County	State	mmbtu/capita	mmbtu/$1000
51077	Grayson	VA	194	4.7
13157	Jackson	GA	193	6.0
13187	Lumpkin	GA	193	5.3
51913	Carroll + Galax	VA	192	5.1
28093	Marshall	MS	191	4.4
45073	Oconee	SC	189	6.1
42031	Clarion	PA	183	5.3
1115	St. Clair	AL	182	5.3
1043	Cullman	AL	180	5.3
54037	Jefferson	WV	178	6.4
28057	Itawamba	MS	178	4.8
37003	Alexander	NC	177	5.2
37099	Jackson	NC	175	4.8
1127	Walker	AL	175	4.9
36003	Allegany	NY	173	4.1
13227	Pickens	GA	172	5.8
42009	Bedford	PA	168	4.5
42117	Tioga	PA	145	3.7
1107	Pickens	AL	142	3.7
51167	Russell	VA	137	3.3
54065	Morgan	WV	126	4.2
42115	Susquehanna	PA	122	3.4
42127	Wayne	PA	79	2.4
37039	Cherokee	NC	54	1.3
42103	Pike	PA	29	0.9
51105	Lee	VA	29	0.7