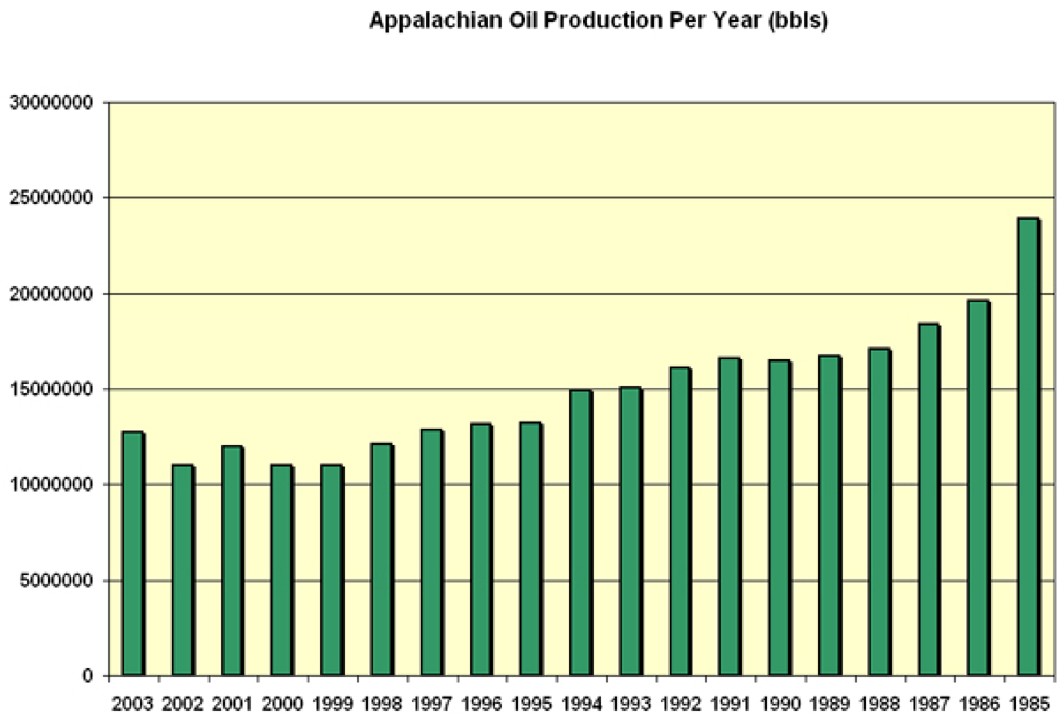
Part Two: Energy Supplies and their Probability of Utilization in the ARC region

This portion of the report is a survey of the conventional and potential alternative energy sources of the 410 Appalachian counties. County potential for each energy resource is assessed in qualitative or semi quantitative terms. None of the values represented below should be used beyond the intent of this report which is to simply rank counties by potential. The qualitative measures are based on subjective break points in a measured value that is strongly correlated with the magnitude of the energy resource under consideration. Many of the underlying values are model results or estimates thus the errors are assumed to be high but systematic thus qualitative and semi-quantitative ranking of counties is justified. The term "resource" used throughout this page is the sum of an energy source but not it's recoverable value. The term "reserve" is used to represent recoverable volumes or masses of an energy commodity at prices and efficiencies that existed at the time of the reserve estimation.

Petroleum

Though U.S. commercial production of petroleum for fuel was initially in Appalachia (Pennsylvania), prospects for significantly increasing production in Appalachia are low. Production, reserves, and exploration activity as measured by wells drilled are summarized in the next three graphs. Reserves have increased in the last few years likely to be due to rising prices, not discovery of new sources of petroleum.


Appalachian Oil Production Per Year (bbls)
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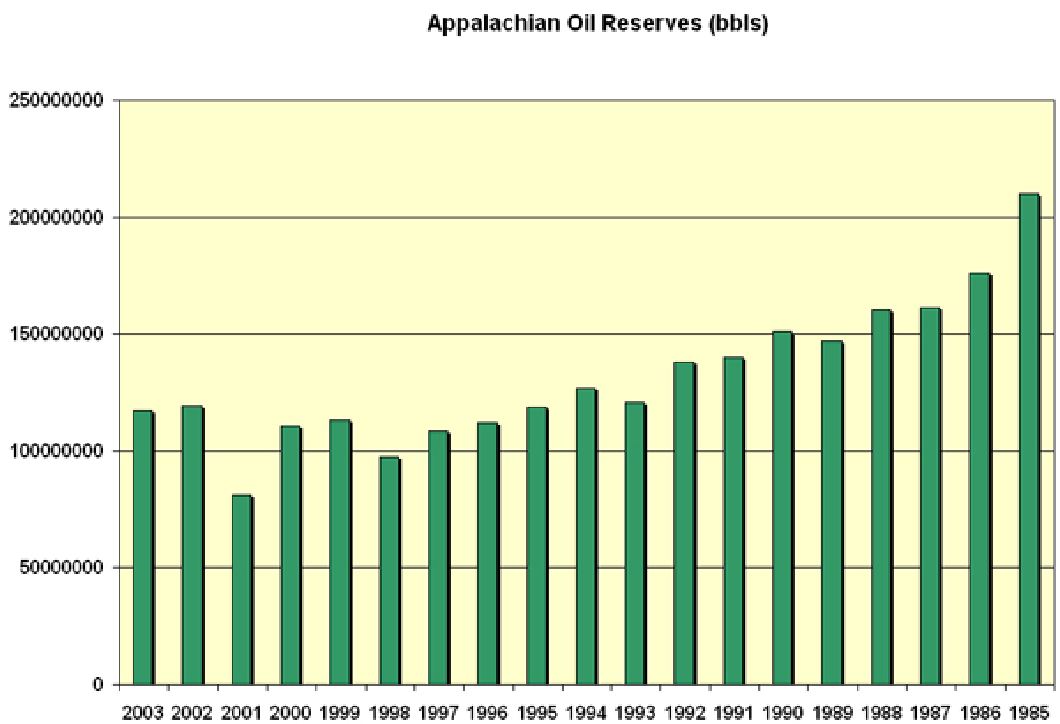
2003 2002 2001 2000 1999 1998 1997 1996 1995 1994 1993 1992 1991 1990 1989 1988 1987 1986 1985


Appalachian Oil Reserves (bbls)
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200000000
150000000
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50000000
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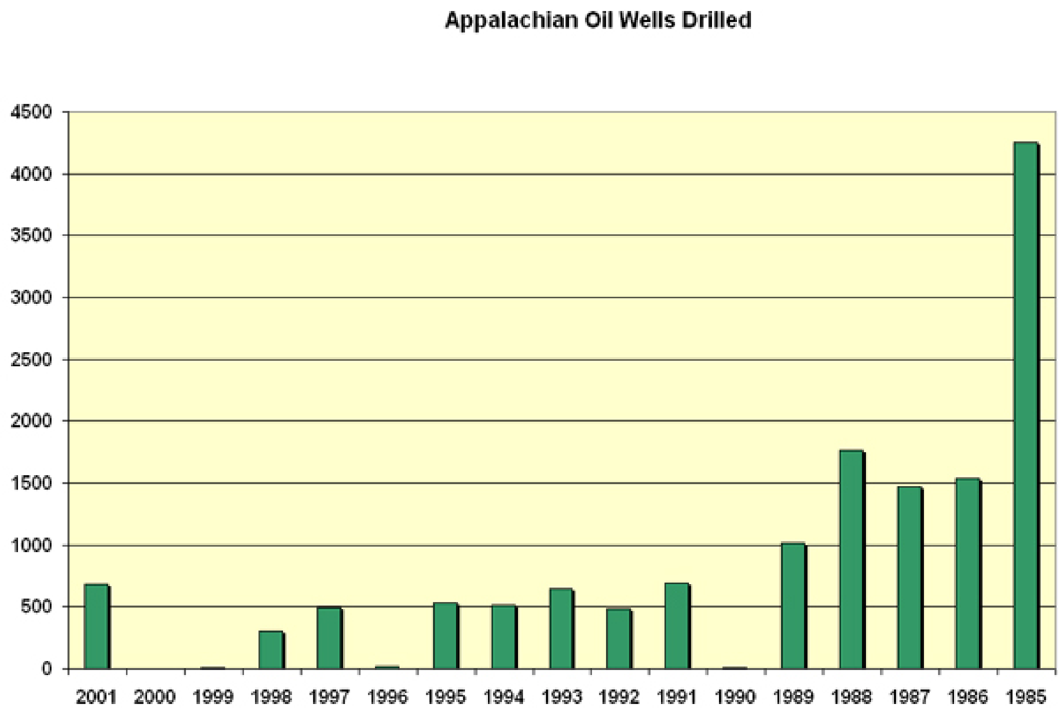
2003 2002 2001 2000 1999 1998 1997 1996 1995 1994 1993 1992 1991 1990 1989 1988 1987 1986 1985



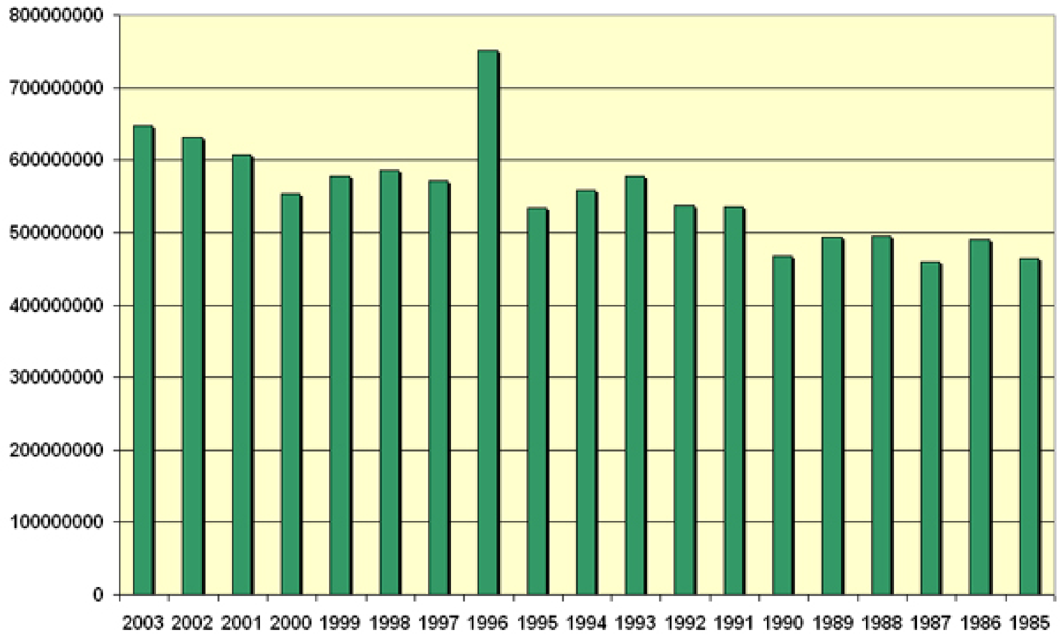
Source: Petroleum Technology Transfer Council Appalachian Region Oil and Gas Data

Natural Gas

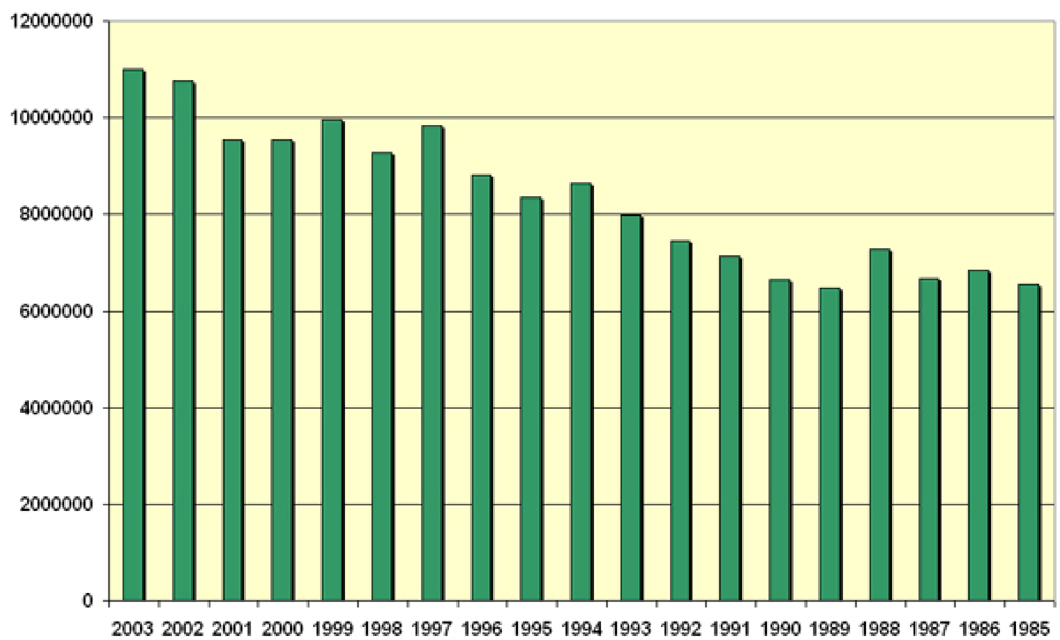
Natural gas exploration in Appalachia has increased recently in response to rising natural gas prices and a ready local market. Direct employment associated with increased exploration includes engineering, road construction, drilling, and oil field services. Indirect employment associated with exploration includes housing, meals, and fuel for equipment. New production inputs are primarily associated with constructing production wells, pipelines, pipeline roads, and compressor stations. Long term employment is limited to gas field service and maintenance.

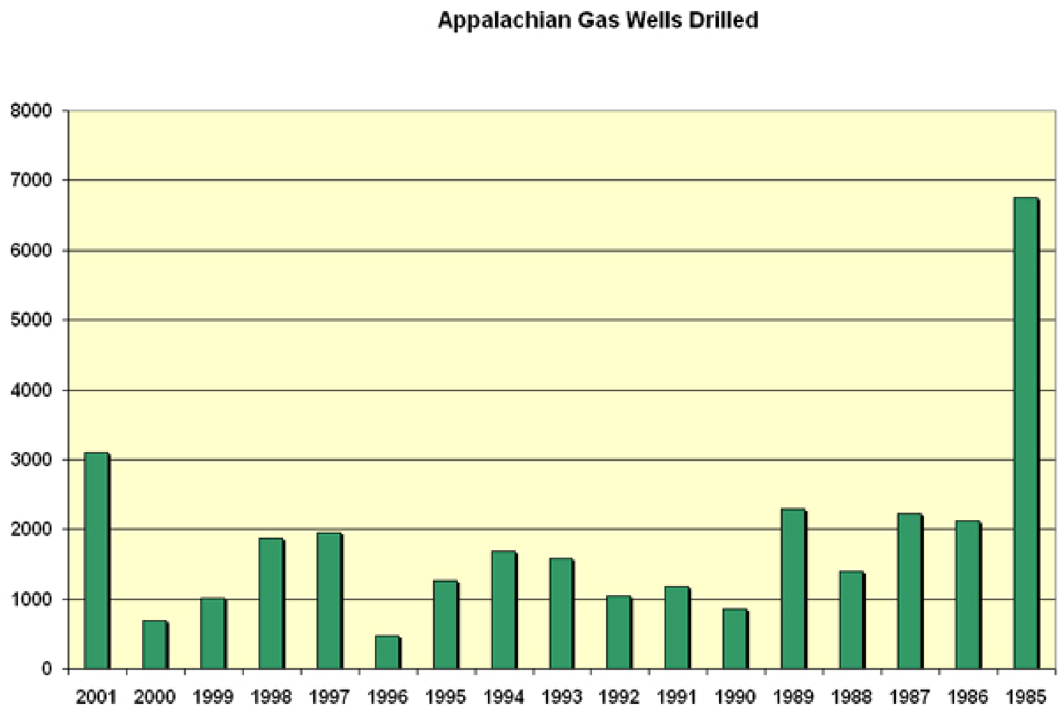
Historic natural gas production, reserves, and exploration activity are summarized in the following three graphs.

Appalachian Gas Production: (Mcf)



Appalachian Gas Reserves (mcf)

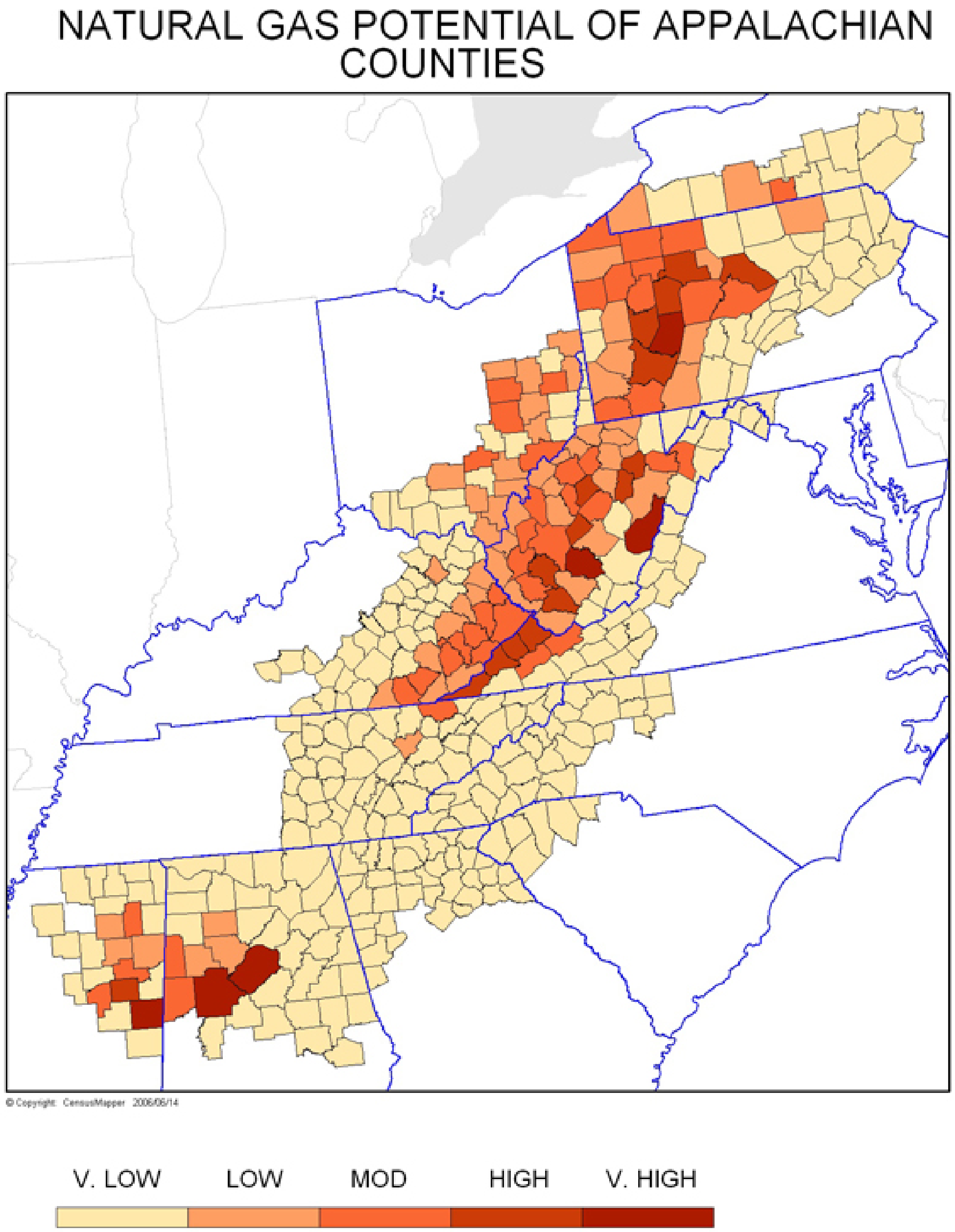




Source: Petroleum Technology Transfer Council Appalachian Region Oil and Gas Data

A qualitative assessment of natural gas potential is shown in the following map. Each county was categorized by the average reserve size class as defined by the Energy Information Administration within each county.

Natural Gas Potential Based on EIA Reserve Estimation for 2001			
Code	Potential	Average Reservoir Size Class	Gas Volume Range for Class (million cubic feet)
	V. Low	0 and 1	0 -10
	Low	2	10.1-100
	Mod	3	100.1-1,000
	High	4	1,000.1-10,000
	V. High	5	10,000.1 - 100,000



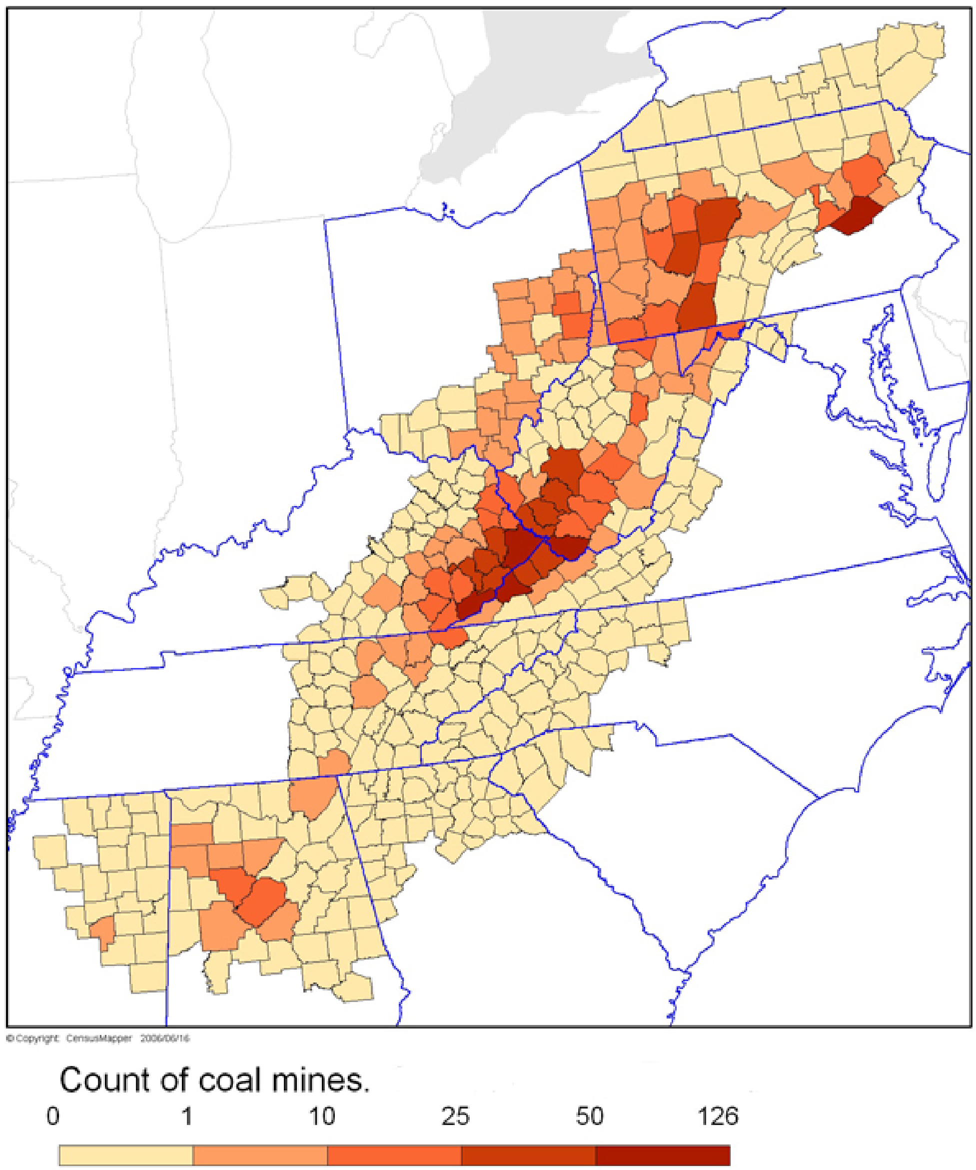
Steam Coal

Coal has been Appalachia's traditional energy product. Fourteen hundred and seventy five mines produced 3.79 million tons of steam coal in 2003 (most recent year statistics are available) and employed nearly 47,000 people. The cumulative value of all coal produced in Appalachian counties priced as bituminous coal FOB was $10.7 billion dollars (current

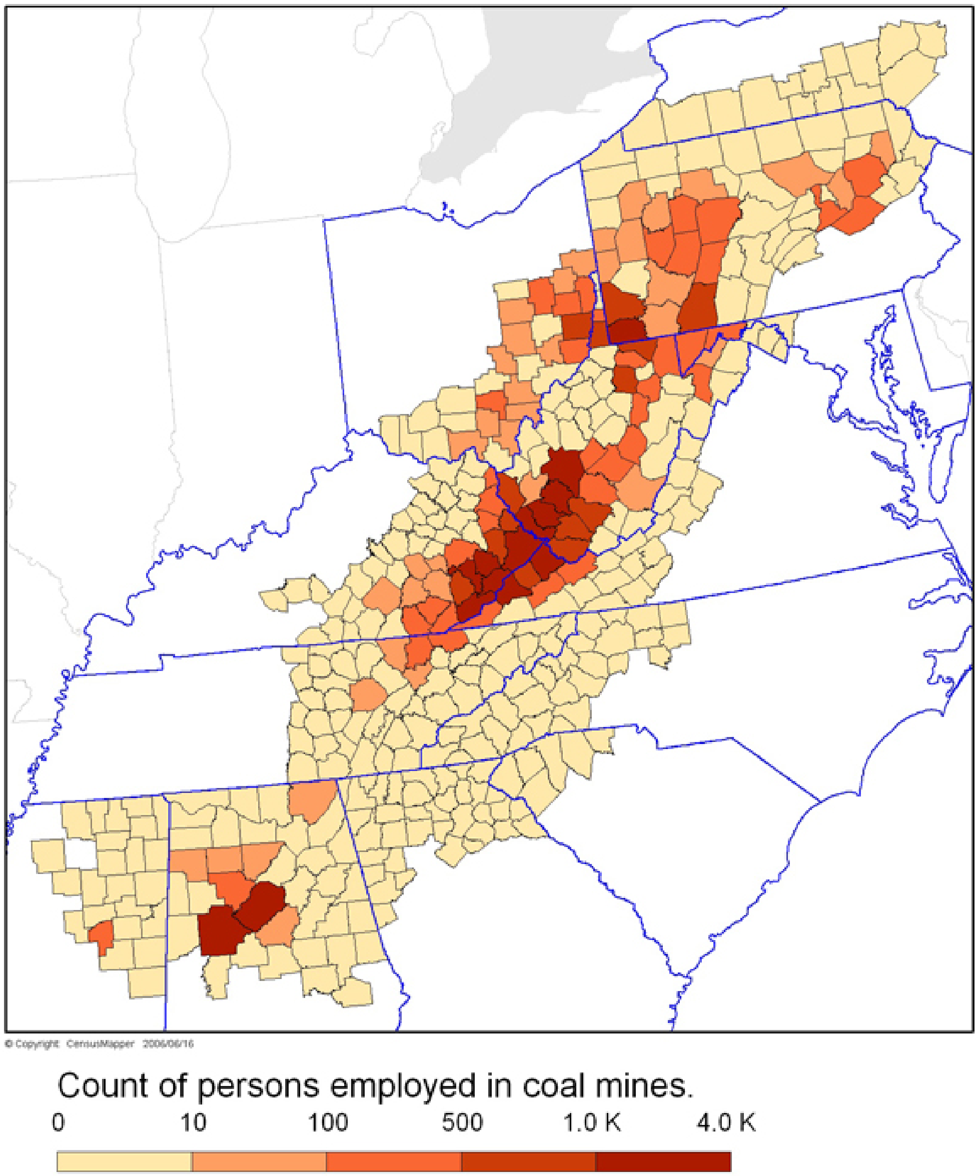
2005 dollars). Rising prices and increased productivity through automation have stimulated production, redevelopment of closed mines, and initiation of new mines.

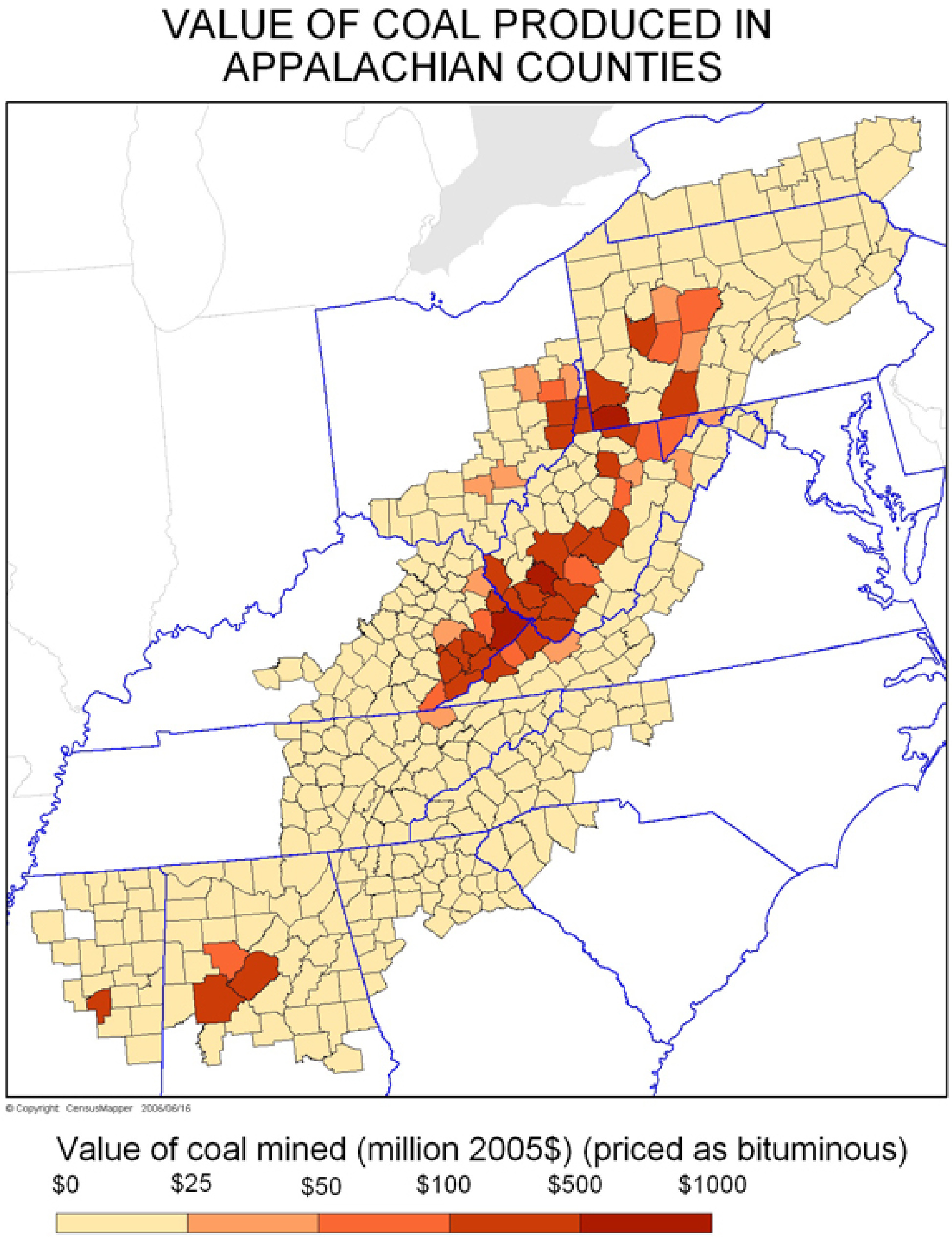
The next three maps summarize mines, value and employment for 2003 (most recent data available) by county.

COAL MINES IN APPALACHIAN COUNTIES



EMPLOYMENT IN COAL MINES IN APPALACHIAN COUNTIES





Source: Energy Information Agency

Coalbed Methane

Significant resources of coal that are not economic to mine exist in Appalachian counties and may represent a source of energy via in situ coal gasification. Additionally, methane constitutes a small but potentially useful fraction of the ventilation stream from operating mines.

Underground Coal Gasification

Underground coal gasification was developed by the Soviets in the 1930's, tried in the United Kingdom in the 1950s, evaluated in the US in the 1970s, and evaluated in Europe during the 1990s. Active research programs exist in all the major coal producing countries. Simple in theory but difficult to put in practice, coal gasification requires injection wells and extraction wells in a coal seam. Controlling the reaction of in situ coal to gas, enhancing coal bed permeability, and maintaining formation pressure are all major challenges. Recent developments in directional (horizontal) drilling may be changing the feasibility of this technology.

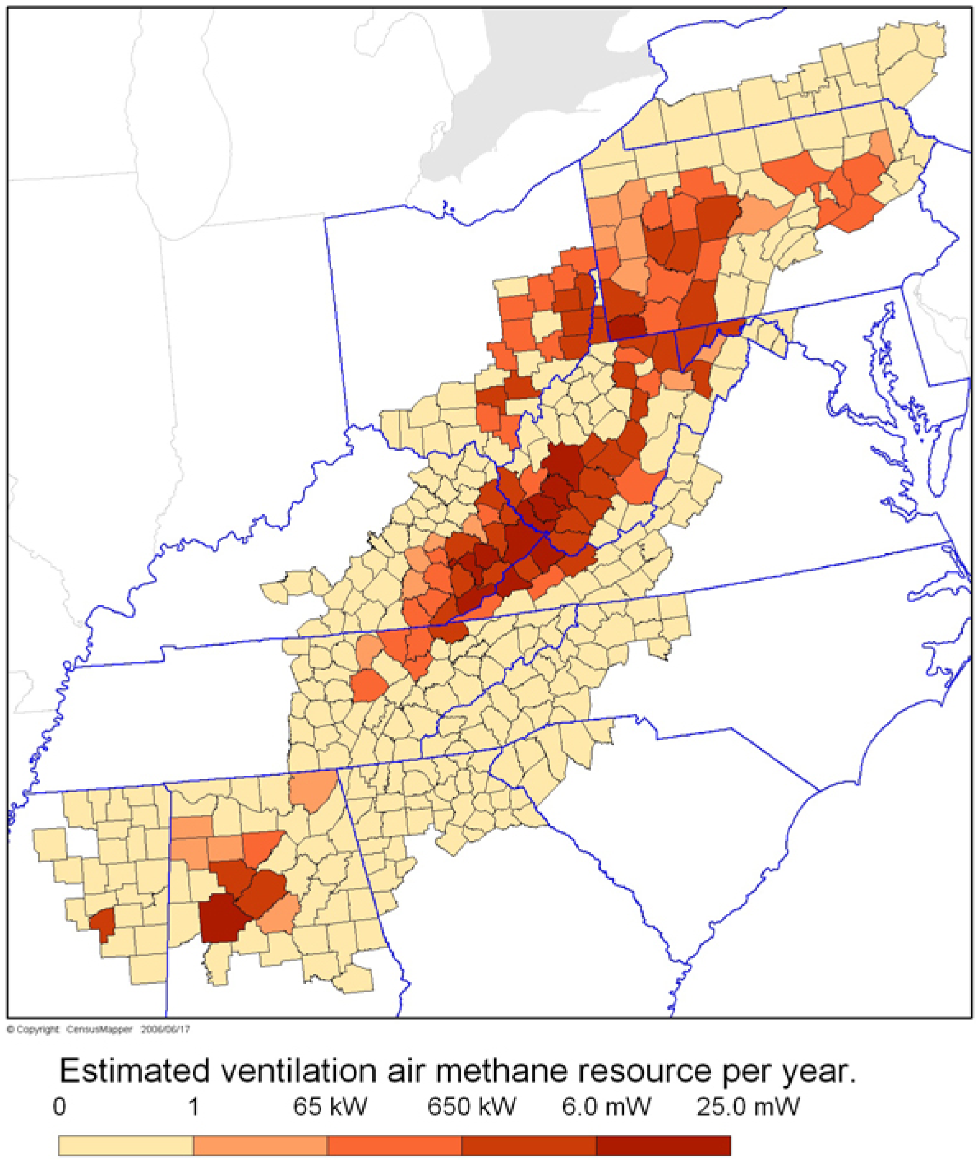
Little literature is available at US websites and a search of the EIA and NREL websites turned up few relevant references. Leaders in the field appear to be the United Kingdom and Australia.

Ventilation Air Methane

Underground coal mines must circulate fresh air to remove flammable and toxic gases released from coal seams during the mining process. As the ventilation air passes through the mine it accumulates carbon dioxide and methane before it is exhausted to the atmosphere. Ventilation air methane (VAM) is the single largest source of industrial methane put in the atmosphere by the United States.

VAM can be utilized as a heat source or to generate electrical power using emerging VAM oxidation technologies. EPA has estimated that VAM based methane emissions from US underground coal mines were on the order of 2.5 billion cubic meters in 2000. The Appalachian basin accounted for 73% of all national underground production in 2000 thus approximately 1.8 billion cubic meters of methane was potentially available for energy production in 2000 in the Appalachian Region. This represents a resource of 175 megawatts per year. The approximate distribution of this resource, coal production by Appalachian county was converted to a VAM resource in the following map.

VAM RESOURCE IN APPALACHIAN COUNTIES



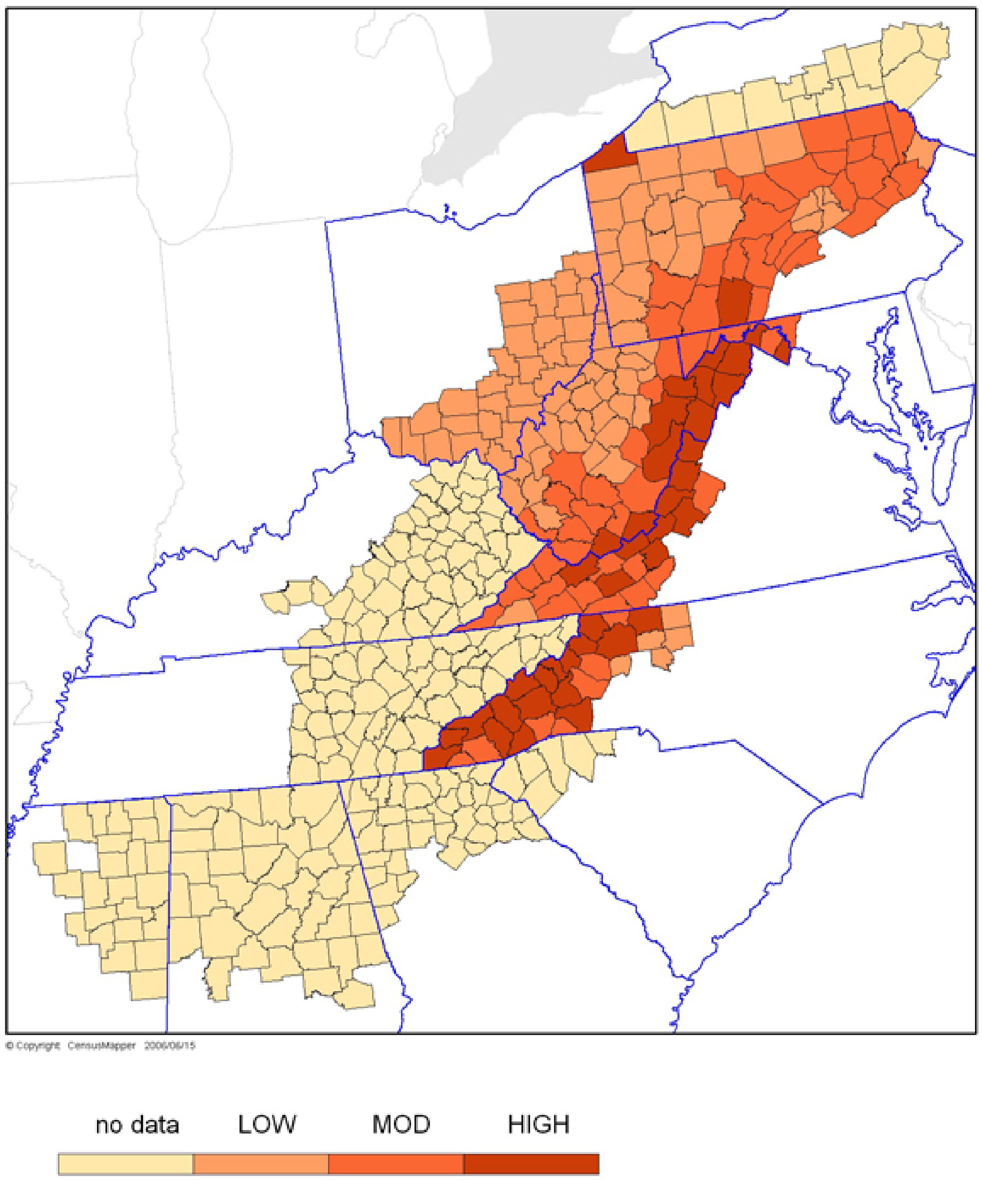
Wind

The Appalachian ridges and Lake Erie shoreline constitute a potential economic zone for generating electricity with wind power. Direct employment is heavily weighted to the construction phase as towers, turbines, power lines, and substations are constructed. Long term employment is limited to maintenance.

The map below is a qualitative assessment of the wind resources of Appalachian counties based on state level evaluations assembled by the

Department of Energy. Each county was assigned a value based on the presence and areal coverage of class 4 and above wind speed at 50 meters above the ground.

WIND POTENTIAL OF APPALACHIAN COUNTIES



Wind Potential From DOE			
Code	Potential	Max Wind Class	Wind Speed at 50 m (mph)
	no data	-	-
	Low	<4	<15.7
	Mod	4 - 5	16.8 - 17.9
	High	>5	>17.9

Lignocellulose

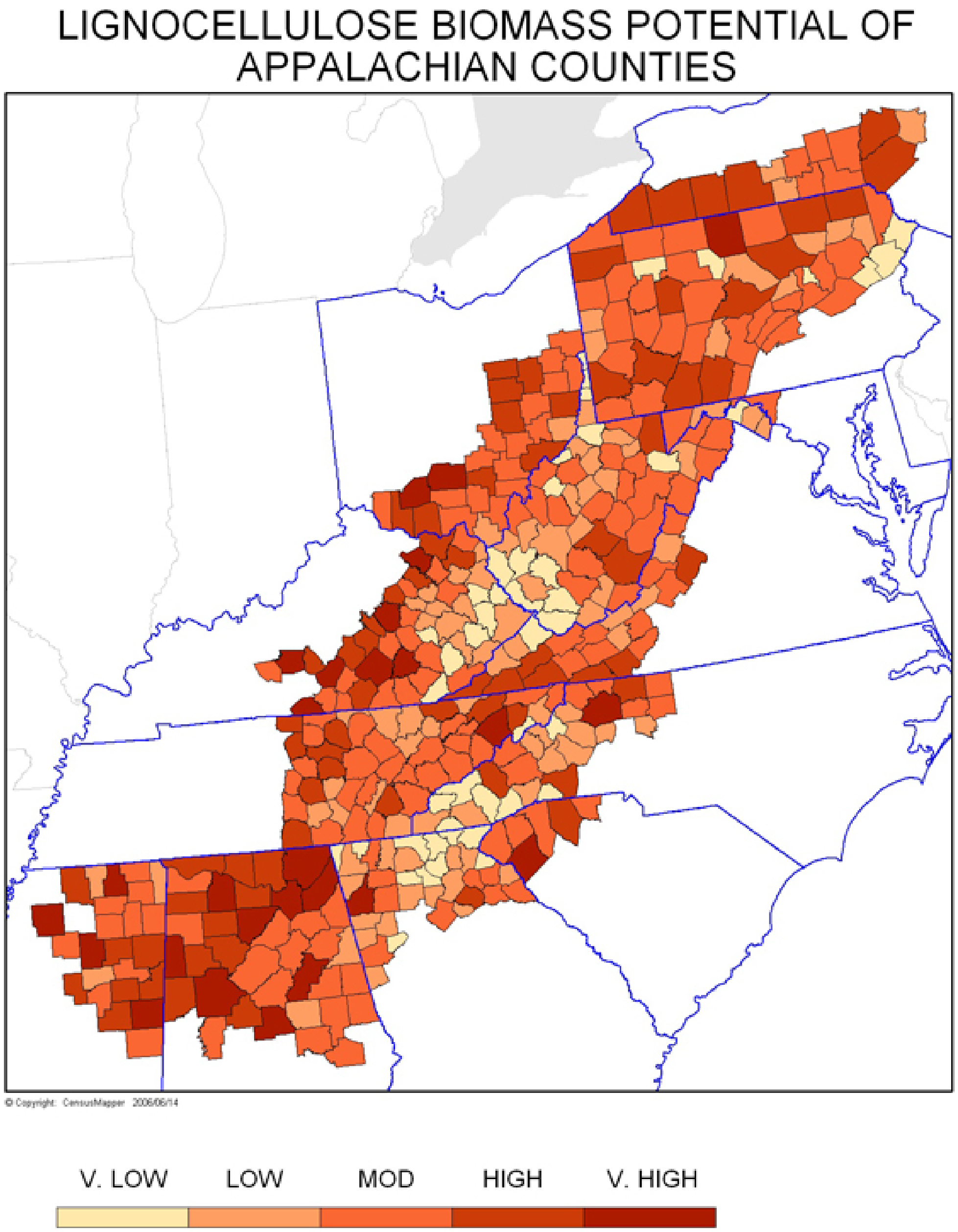
Lignocellulose is a promising feedstock for fuel grade ethanol production. Sources of lignocellulose include wood chips, corn stover (chopped corn stalks), and "bioenergy crops" such as switchgrass and fast growing trees. The National Renewable Energy Laboratory has produced an extensive analysis of current and near term technologies for developing renewable energy sources including ethanol production from lignocellulose. The following analysis of the lignocellulose potential of Appalachian counties is based on a modified inventory of lignocellulose sources by county and a pre-feasibility study of a model biorefinery for ethanol production both produced by NREL.

The inventory of lignocellulose resources by county is composed of feedstocks from crop residues, forest residues, urban waste wood, mill residues, and dedicated energy crops. The NREL inventory included switchgrass as its dedicated energy crop and only calculated the amount that could be grown on reclaimed mine land and acreage set aside in the CWRP program. This value has been deleted and a separate value for switchgrass production substituted. The new value is calculated by using the unharvested cropland acreage reported in the 2002 Census of Agriculture multiplied by 5 tonnes/acre/year. This new assumption is justified on the basis of switchgrass as viable in the normal crop rotation cycle and the potential for an incentive program to grow switchgrass on otherwise uncultivated cropland.

Lignocellulose cultivation and local biorefineries to convert it to ethanol represent the single biggest potential gain in local employment and retention of revenue of all energy industries considered in this evaluation. This industry, like coal, depends upon the local labor force to produce the feedstock and if the biorefineries are local, supply the labor force to operate them as well. Local input may account for as much as 60% of the total cost of production.

The classification of counties is based on the total tonnage of biomass from all sources and the threshold capacity for a 25 million gallon/year ethanol biorefinery with minimum feedstock input of ~300,000 tons per year presented in the pre-feasibility study produced by NREL. Counties with sufficient lignocellulose potential to support a 25 million gallon per year biorefinery are rated "very high".

Lignocellulose Based Ethanol Potential Based on NREL		
Code	Potential	Tonnes/yr Lignocellulose production
	V. Low	<50,000
	Low	50,000 - 100,000
	Mod	100,000 - 200,000
	High	200,000 - 300,000
	V. High	>300,000

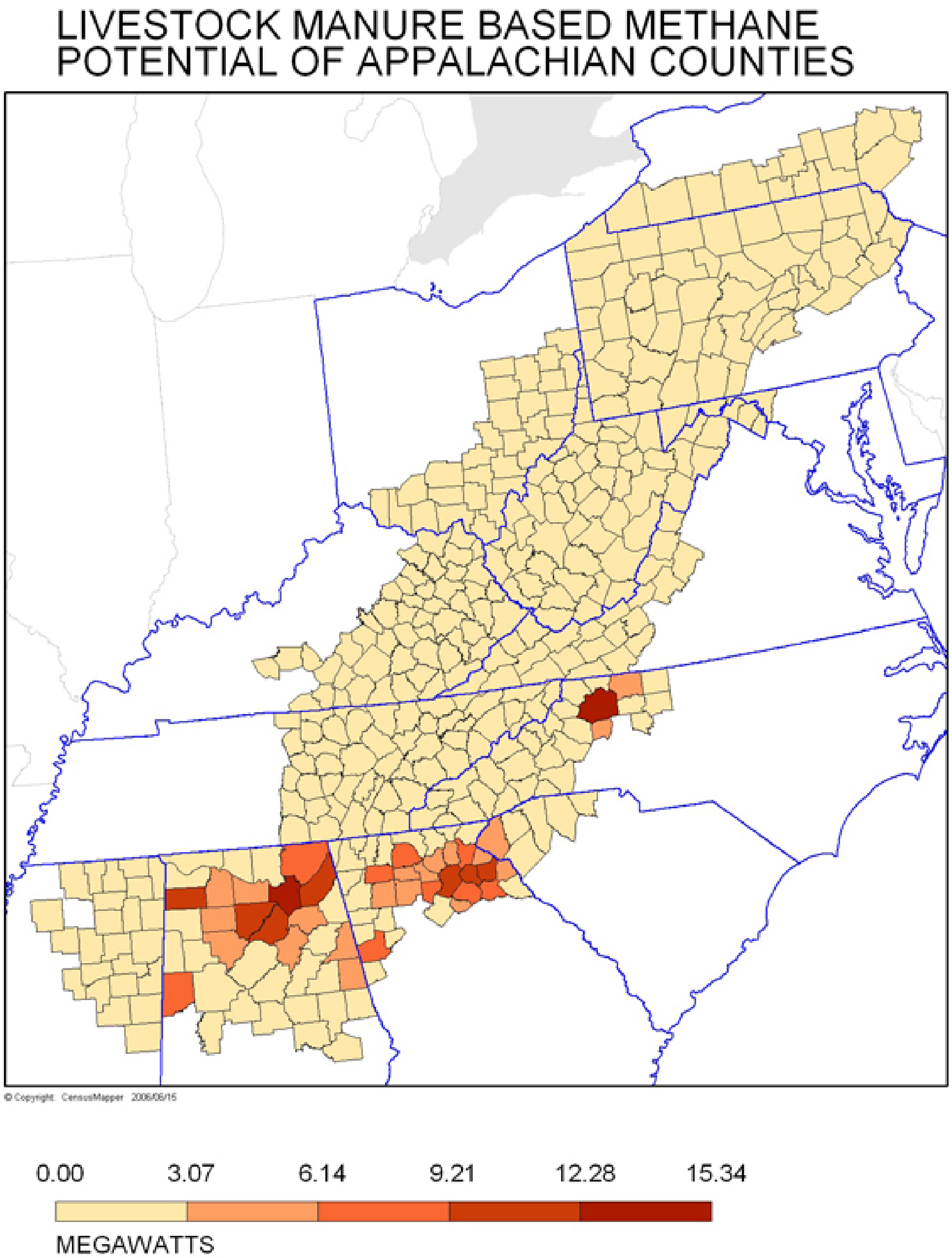


Biomass Methane

Biomass feedstocks can also be used to produce methane, a significant greenhouse gas, but also a potential source of energy. NREL has estimated the annual methane production by county from landfills, wastewater treatment, and livestock manure. Units used in their analysis are tonnes/year methane. This was converted to megawatts. Each methane feedstock (waste water, manure, and landfill) requires a separate extraction technology though conversion to electricity or direct thermal use is consistent over each of the three sources.

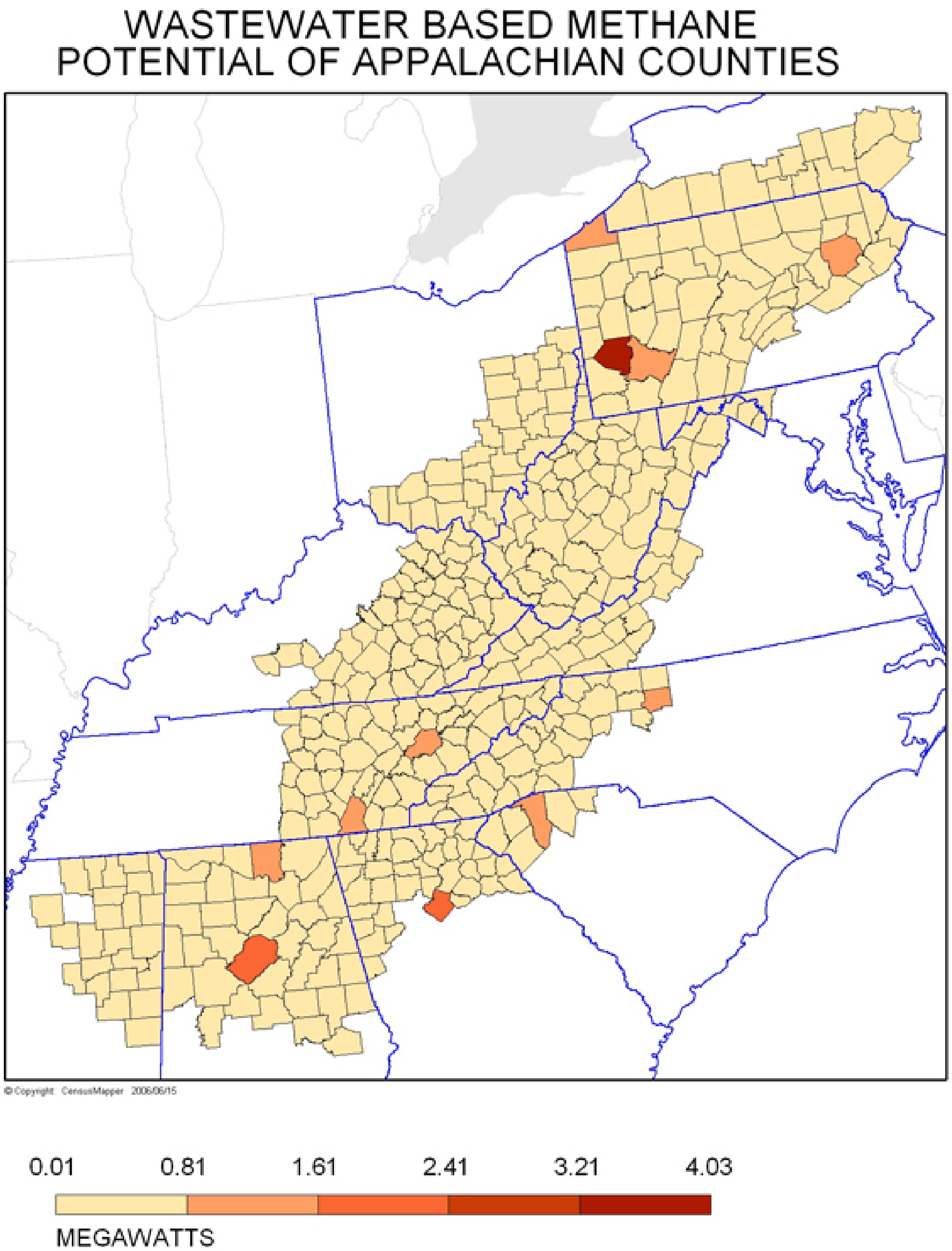
Livestock Manure

Livestock manure can be used to produce electricity or heat by anaerobic fermentation. Small scale conversion units are being developed for family farms and larger industrial scale plants for factory farms and feedlots. Cost per animal unit remains high for small scale operations and safety risks handling combustible gas may be significant (Source: Purdue Univ).



Wastewater Treatment

Wastewater treatment plants can produce valuable methane from solid waste by anaerobic fermentation. Methane can be used to produce electricity or burned directly for thermal energy. The wastewater resource was converted from tonnes to megawatts to rank the Appalachian counties mapped.



Landfill

Landfill based methane can be converted to electrical energy by several means or used onsite for thermal energy. The EPA lists 326 electrical generation projects proposed or operational nationally as of 2004 and 92 direct use projects proposed or operational. Approximately 65% of the electrical generation projects underway nationally use methane to directly power reciprocating engines (internal combustion engine) to drive a generator. Gas fired turbines comprise approximately 13% of current electrical generation followed by microturbines (~6%), steam boilers (~5%), cogeneration (~4%), and other means.

Direct use employs the heat of burning methane for onsite industrial use.

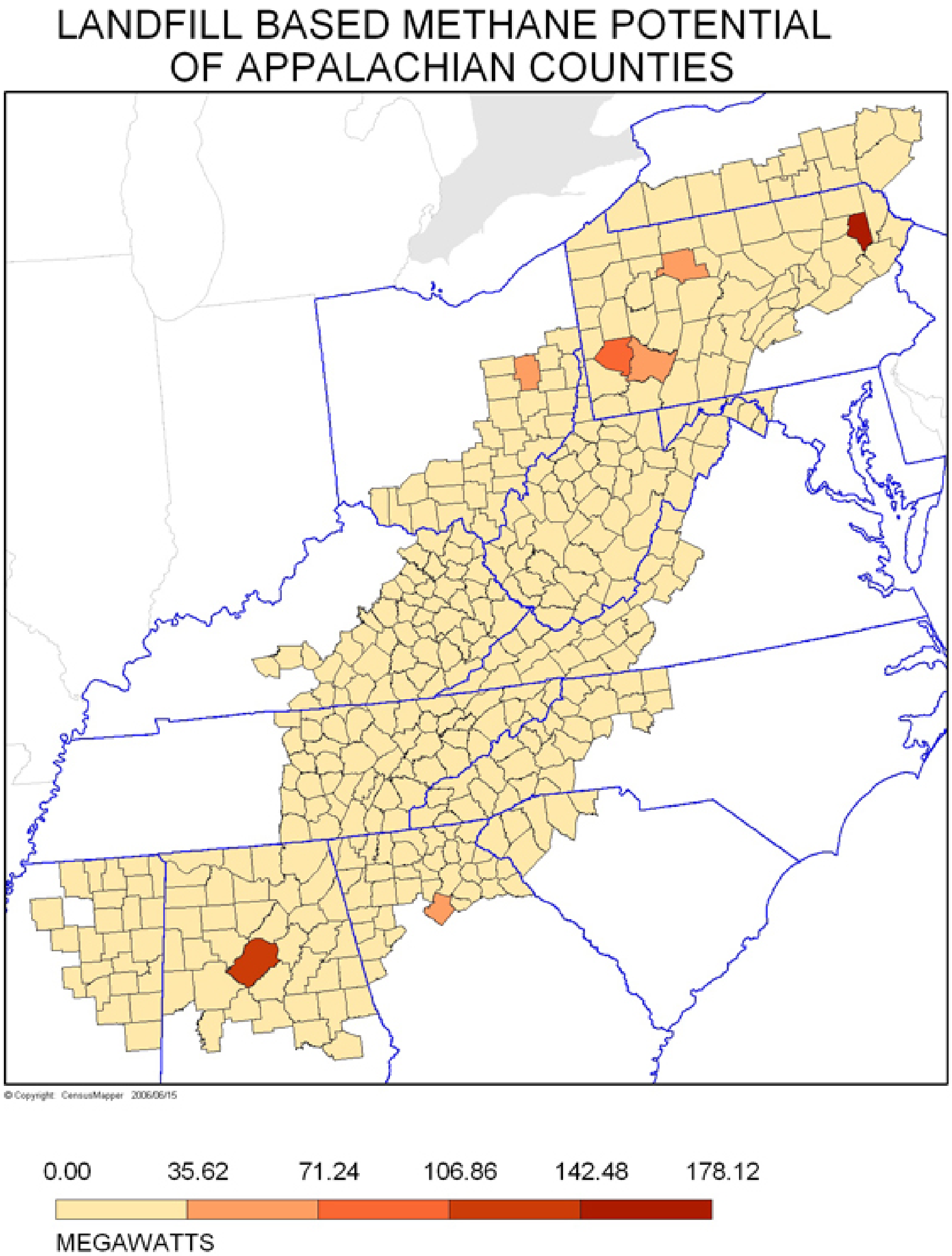
The EPA estimates that each megawatt of landfill energy during the construction phase employs 23 people and generates $1 million in wages and salaries.

Source: EPA

Only a very small portion of landfill methane in Appalachian counties is currently being utilized.

Operational Landfill Electrical Generation		
State	County	Capacity (megawatts)
PA	Lackawanna	6.6
PA	Erie	6.1
PA	Lycoming	13
PA	Bradford	0.8
KY	Greenup	3.2
KY	Laurel	4.0
TN	Anderson	3.2
TN	Hamilton	1.0
NC	Forsyth	4.6
NY	Broome	1.2

Source: EPA

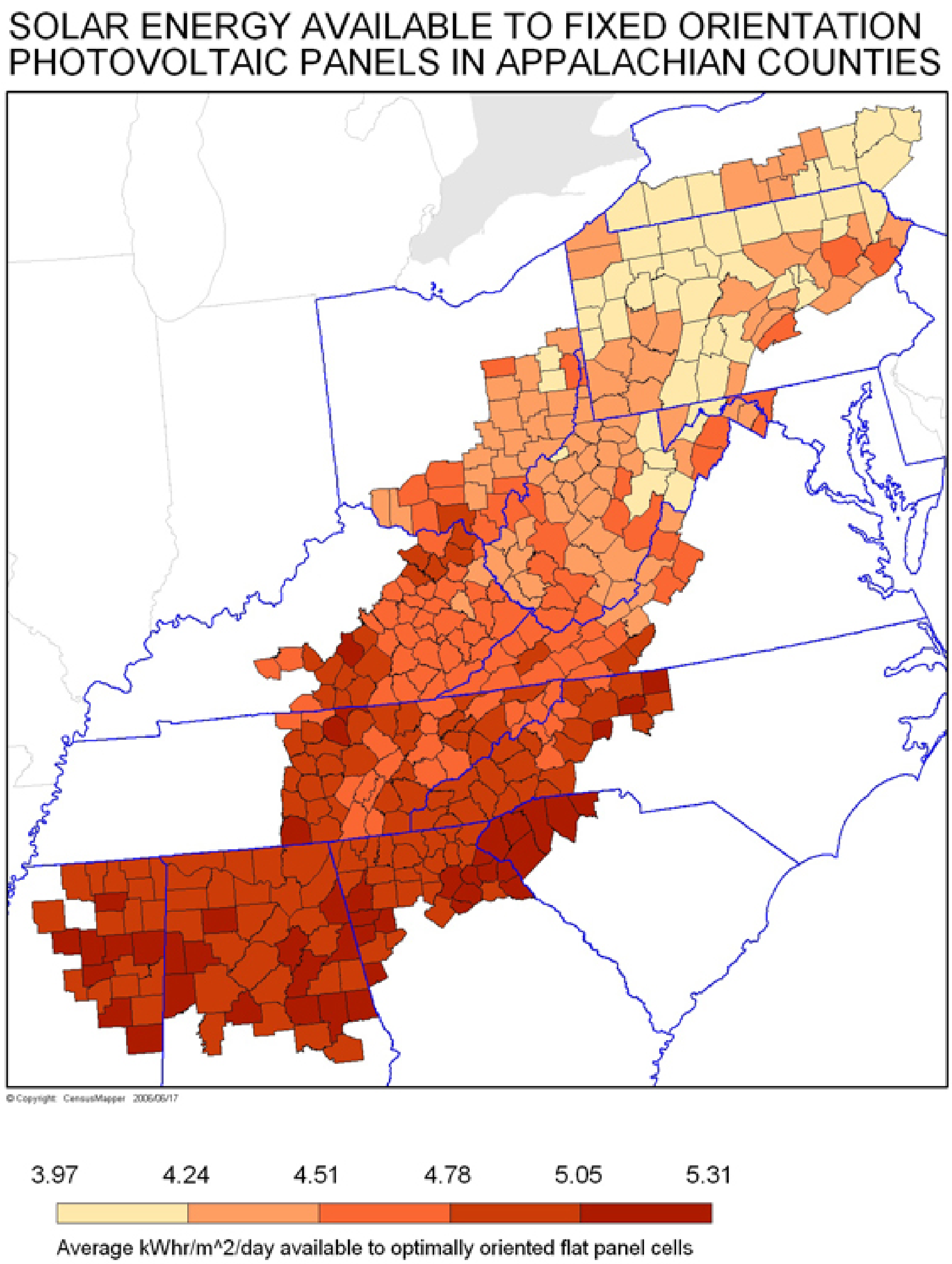


Solar

Conversion of solar radiation to electricity by several technologies depends upon factors of scale, angle of incident solar radiation, temperature, cloud cover, and atmospheric clarity. Small scale conversion utilizing fixed orientation flat panel photovoltaic cells serves remote equipment installations, homes and commercial buildings. Solar conversion linked to the power grid utilizes more capital intensive technologies and/or larger operating scales such as concentrating solar generation.

Photovoltaics (PV)

The following map utilizes a geographic-climatologic model of average potential solar energy developed by NREL for evaluating PV cells.



Concentrating Solar Systems

Concentrating solar systems including trough, concentrating dish, and motorized photovoltaic array technologies are necessarily more capital intensive and represent a potential type of commercial power generation in Appalachian counties. The following map displays the solar insolation values available to concentrating solar technologies. Appalachian counties in general are far less attractive than counties in the western United States where solar resources are greater and land costs are lower.