1 INTRODUCTION

Perhaps at no time since the mid-1970s has the Appalachian Region faced so many energy challenges. Fuel prices for oil, gasoline, natural gas, and coal have risen dramatically and now match or exceed previous all-time highs. These spiraling costs are compounded by double-digit economic growth rates in China and India, which are driving up the cost of steel, aluminum, and other materials necessary to expand the Region‘s energy infrastructure. The growing reliance on oil imports raises questions about the long-term energy security of the Region‘s petroleum-dominant transportation system. Concerns about greenhouse gas emissions and mountaintop removal are placing new constraints on coal mining and the construction of coal plants, resulting in numerous cancelled projects and the loss of billions of dollars.[1] ―Not in my backyard” (NIMBY) attitudes have allowed local opposition to routinely trump regional needs for new energy resources and infrastructure.

After decades of steadily expanding energy consumption, it is hard to imagine how another 25 years (or century) of similar growth in energy demand can be accommodated. As a result, policymakers at all levels of government want to know how much of the forecasted growth in energy consumption can be met by improved energy efficiency. They also want to know what types of policies, programs, and technologies hold the greatest potential to curb the growth of energy consumption – at the least cost. *Energy Efficiency in Appalachia* focuses on these issues.

1.1 RATIONALE AND GOALS OF THE STUDY

In 2006, the Appalachian Regional Commission (ARC) prepared a report – *Energizing Appalachia: A Regional Blueprint for Economic and Energy Development* – that documented the energy situation within the Appalachian Region. It also articulated the ARC energy goal: ―Develop the Appalachian Region‘s energy potential to increase the supply of locally produced, clean, affordable energy, and to create and regain jobs” (ARC, 2006). Three strategic objectives support this goal, focusing on the development of energy efficiency, renewable energy, and conventional energy resources within the Region.

In conjunction with the development of *Energizing Appalachia,* ARC commissioned two studies, one on the *Economic Development Potential of Conventional and Potential Alternative Sources in Appalachian Counties* (Glasmeier and Bell, 2006) and another on *Energy Efficiency and Renewable Energy in Appalachia: Policy and Potential* (Center for Business and Economic Research (CBER), 2006). Together these reports provide a detailed assessment of conventional and unconventional fossil energy sources as well as the full range of renewable energy resources. The potential for energy-efficiency improvements in the Region, however, is treated more anecdotally by highlighting some of the Region‘s innovative energy-saving system designs, reviewing energy-efficiency policies, and comparing energy intensity levels in the Region to those of the nation. Although there have been a large number of studies highlighting positive opportunities for energy-efficiency investments in individual states, across the nation, and even within various states within Appalachia (Laitner and

[1] There are many examples of recently cancelled coal plant projects in the Appalachian region. For example, several years ago American Electric Power (AEP) proposed to build the Mountaineer integrated gasification combined cycle (IGCC) coal plant next to the existing Mountaineer generating station along the Ohio River in Mason County, West Virginia. In April 2008, the West Virginia State Corporation Commission (SCC) rejected the plant after judging that its cost estimates were not credible (http://www.sourcewatch.org/index.php?title=Mountaineer).

McKinney, 2008a), there is no current quantitative estimate of the economic potential for energy-efficiency improvements for the Region as a whole.

To fill this gap, *Energy Efficiency in Appalachia* assesses the potential for cost-effective energy-efficiency gains across the Region's residential, commercial, industrial, and transportation sectors. With 2006 as a baseline, it focuses on projections for the years 2013, 2020, and 2030 under the assumption that transformative energy policies are adopted within the Region in the year 2010.

Evidence is mounting that energy efficiency is a large, affordable, and feasible energy resource. It can be as reliable as the construction of new power plants and the purchase of power via long-term contracts or spot markets. It has been shown to be a valuable, ―front-line" strategy against global climate change because it offers a ―no regrets" approach: investments in energy efficiency can save consumers and businesses money while reducing pollution and greenhouse gas (GHG) emissions.[2]

A large potential for improved efficiency exists in numerous appliances and energy-consuming equipment and practices. For instance, high-quality adjustable-speed electronic motor drives, once exotic and costly, are now mass-produced in Asia and are widely used because of their protective and soft-start circuits. High-efficiency compact fluorescent lamps sell for a fifth of their 1983 price, now that a billion are made yearly. Real prices have fallen several fold in 15 years for electronic lighting ballasts and heat-reflecting window coatings. Hybrid electric cars offer fuel economy performance in a standard range vehicle that was unachievable ten years ago. The economic potential for energy efficiency continues to grow (Lovins, 2007).

States across the nation are meeting one to two percent of their electricity consumption each year with energy efficiency at a cost of approximately $0.03 per kilowatt-hour (kWh) compared with projected costs of $0.05 to $0.07 per kWh of electricity from coal, gas combined cycle, wind or nuclear plants (Brown and Chandler, 2008; Kushler, York and Witte, 2004). Results from California, New York, Vermont, and other states show that energy efficiency represents a low-cost, low-risk energy strategy.

California, in part due to aggressive and sustained energy-efficiency measures, has kept per capita electricity use flat over recent decades (National Academy of Sciences, 2008). This is in direct contrast to national trends over the last 25 years, where U.S. per capita electricity use as a whole has risen about 50 percent. Rufo and Coito (2002) have shown that the potential for further energy-efficiency improvements in California remains strong. A similar potential for aggressive and sustained energy-efficiency programs has been demonstrated in Vermont and other states, where electricity consumption per capita has remained fairly flat while the state's economy has grown significantly. Thus, these states have shown that energy demand growth can be significantly reduced without compromising economic growth. The challenge is to move these energy-efficiency ―best practices" to the rest of the country.

[2] Indeed as the meta-review provided by Laitner and McKinney (2008a) suggests, the evidence points to a potential 20 to 30 percent efficiency gain compared to normal business-as-usual projections. Perhaps more critically, the benefits of this level of potential efficiency improvement appear to outweigh the costs by roughly two-to-one.

Together, energy efficiency and demand response can delay or completely avoid the need for expensive new generation and transmission investments, thus keeping the future cost of electricity affordable and freeing up energy dollars to be spent on other resources to expand the Region's economy. A greater share of the dollars invested in energy efficiency goes to local companies that create new jobs compared with conventional electricity resources where much of the money flows out of the Region to equipment manufacturers and fuel suppliers.

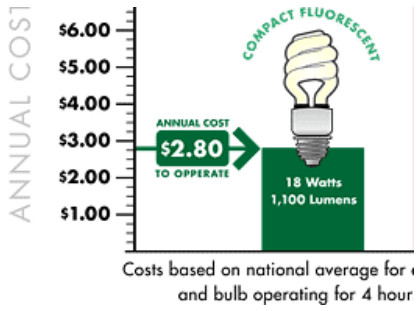

Figure 1.1 The Economics of Compact Fluorescent Light Bulbs
(Brown, 2008)

Layers of energy inefficiency exist throughout the economy. For example, converting coal at the power plant into useable light given off by incandescent lamps is only three percent efficient (National Academy of Sciences, 2008). By simply replacing incandescent bulbs with *compact fluorescents*, a four-fold improvement in efficiency can be achieved. Consider the economics shown in Figure 1.1. The payback period can be quite short – in this case for compact fluorescent light (CFL) bulbs, less than a year or as little as a month, depending on how may hours each day the CFL is used. However, as with many (but not all) energy-efficiency improvements, consumers need to purchase a more expensive device in order to generate the energy savings. How can reluctant consumers be persuaded to pay more up front to save money in the future when they often do not understand the sometimes complex economic analysis that goes into such a purchasing decision?

Energy-efficiency policy mechanisms are numerous and are implemented at all levels of government from the local jurisdiction and state to the regional and national scale. To make matters more complicated, energy-efficiency measures and incentives can be delivered by a multiplicity of actors and agents, including independent organizations, non-government statewide organizations, fully integrated independently owned utilities, unaffiliated distribution companies, as well as government agencies (Harrington and Murray, 2003). In this report, we use the typology developed by Geller (2003) to inventory existing policies and to consider alternatives (see Appendix A). Geller's typology includes regulatory policies (regulations, market obligations, and market reforms); fiscal measures (financial incentives, financing, and pricing); enabling policies (capacity building, dissemination and training, and research, development, and demonstration); and voluntary approaches (planning techniques, procurement policies, and voluntary agreements).

By expanding existing energy-efficiency policies and by implementing new policy approaches that tackle key barriers, create new incentives, set minimum standards, and enable change, how much energy efficiency can be stimulated? Which technologies hold the greatest potential and what policies and programs can most effectively translate that potential into reality? These are the essential questions addressed by this study.

1.2 BACKGROUND

1.2.1 Overview of the Appalachian Region

The Appalachian Region tracks the spine of the Appalachian Mountains, starting in northern Mississippi and sweeping northeast through southern New York. It includes all of West Virginia and parts of twelve additional states: Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia. With a population of 23.9 million in 2006, the Region is home to 7.95 percent of the U.S. population.

In 1965 the Federal government established the Appalachian Regional Commission (ARC), an economic development agency composed of the governors of the 13 states and a co-chair appointed by the president. Local participation is provided by local development districts.

In the early years of the ARC, the Region was divided into three contiguous and relatively homogeneous sub-regions based on topography, demographics and economics (Figure 1.2). The South sub-region has the highest population growth rate (estimated at 1.13 percent annually), while the North has the slowest growth rate (estimated at 0.28 percent). These three sub-regions include 410 counties and contain parts of four Census Divisions. The cross-walk between these three sub-regions, four Census Divisions, and 410 counties is critical to apportioning numerous data elements that are key to the analysis of efficiency resources.

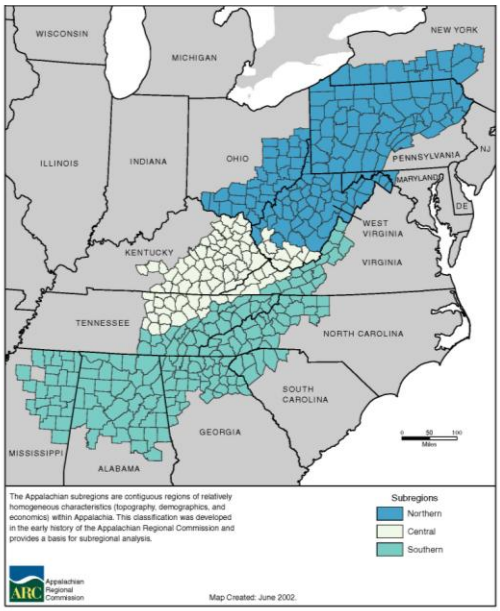

Figure 1.2 Sub-regions in Appalachia
(www.arc.gov/index.do?nodeId=938)

1.2.2 Energy Use in Appalachia

As an historic center of coal production in the United States, Appalachia and energy have been intimately intertwined. Appalachian mines produce 35 percent of the nation‘s coal output, and the Region employs two-thirds of the nation‘s coal miners (ARC, 2006). Much of this coal is burned in Appalachian power plants to produce electricity for the Region‘s consumers and for export to surrounding markets, especially those in the large metropolitan areas that circle the Region. Appalachian coal generated approximately 15 percent of the total U.S. electrical output, worth $16 billion in 2005 (ARC, 2006). Almost 150,000 jobs are generated by the Appalachian energy industry, with hundreds of thousands more producing and distributing energy products and services (ARC, 2006).

The intensity of energy use in the Appalachian Region is slightly higher than that of the nation as a whole. In 2006, the Region consumed 7.94 quadrillion Btu (quads) of energy, or 332.7 MMBtu per capita, slightly more than the U.S. average of 331.6 MMBtu per capita. When indexed to personal income, the Region is considerably more energy intensive than the national average (CBER, 2006, p. 41). According to the CBER (2006), the above-average consumption rates are 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 (p. 42)."

Based on population weighed extrapolations from the Census Division forecasts of energy consumption from EIA's *Annual Energy Outlook 2008*, the Region's energy consumption is expected to grow by 28 percent to 10.14 quads in 2030. This is considerably higher than the 19 percent growth forecast for the U.S. (EIA, 2008a, Table A2).

Table 1.1 Appalachian Region Energy Consumption Forecast from *Annual Energy Outlook*, 2006 to 2030 (quads)
(EIA, 2008a)

Year	Total	Residential Buildings	Commercial Buildings	Industry	Transportation
2006	7.94	1.80	1.50	2.42	2.22
2013	8.45	1.96	1.64	2.51	2.34
2020	9.12	2.16	1.89	2.65	2.42
2030	10.14	2.47	2.26	2.87	2.54

1.2.2.1 Energy Consumption by Source[3]

The Appalachian Region's energy consumption of 7.94 quadrillion Btu in 2006 represents 7.98 percent of the total energy use of the United States. Compared to the share of the energy consumption of each fuel in the United States on average, Appalachia consumed six percent more energy from coal, and three percent more nuclear energy. On the other hand, the Region consumed less energy from oil and natural gas, compared to the national average.

[3] The energy consumption data of the Appalachian region were driven with the projections of business-as-usual scenario from the *Annual Energy Outlook* 2007 (EIA, 2007a). All of the 410 counties included in the region were located over the four census divisions such as the East North Central, East South Central, Middle Atlantic, and South Atlantic regions. Based on the population proportion of Appalachia in each census division, the energy use of the entire Appalachian Region was aggregated. The energy price data of the region was driven from the *Annual Energy Outlook* 2008 (EIA, 2008a). Based on the proportional approach that used in the consumption data, the weighted average of the prices of the four census regions was calculated for this analysis.

Table 1.2 Energy Consumption by Source, 2006
(EIA, 2008a)

Source	United States		Appalachia	
	Quadrillion Btu	Share (%)	Quadrillion Btu	Share (%)
Liquefied Petroleum Gases	2.65	2.7	0.07	0.8
Motor Gasoline	17.62	17.7	1.43	18.0
Distillate Fuel Oil	8.77	8.8	0.74	9.4
Residual Fuel Oil	1.69	1.7	0.15	1.8
Other Liquid Fuels	9.33	9.4	0.58	7.3
Natural Gas	22.30	22.4	1.34	16.8
Coal	22.50	22.6	2.25	28.4
Biofuels and Renewables	6.27	6.3	0.47	5.9
Nuclear Power	8.21	8.2	0.90	11.3
Total	99.52		7.94	

Fuels may not sum to total due to rounding

As is the case nationwide, coal is forecast to increase its share of energy use in the Region between 2015 and 2030, in the absence of restrictions on CO_2 emissions (Table 1.2 and Figure 1.3). However, the market share of western coal is expected to increase, while Appalachian coal production is forecast by EIA to decline slightly.

–Although producers in Central Appalachia are well situated to supply coal to new generating capacity in the Southeast, that portion of the Appalachian basin has been mined extensively, and production costs have been increasing more rapidly than in other Regions." (EIA, 2008a, p. 84) With 67 percent of the nation's jobs in the U.S. coal industry supporting only 35 percent of U.S. coal production, Appalachia has significantly lower levels of labor productivity and therefore higher costs. In contrast, the Powder River Basin has vast remaining surface-minable reserves that can be reached by large earth-moving equipment with significant benefits from economies of scale.

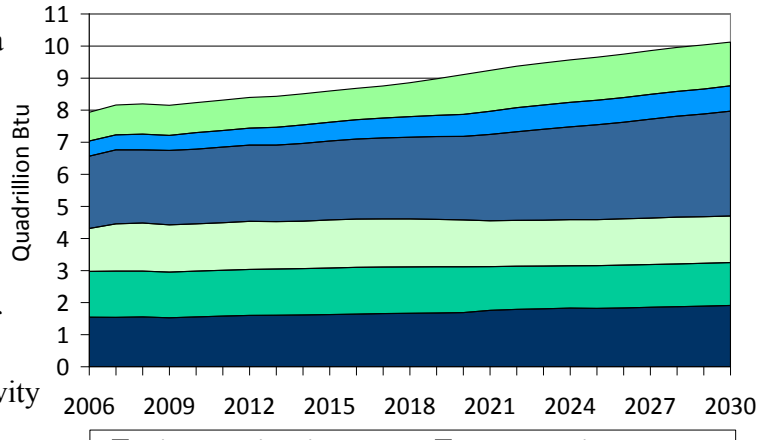

Figure 1.3 Energy Consumption Projections of the Appalachian Region by Source, 2006-2030
(EIA, 2008a)

1.2.2.2 Energy Consumption by Sector

In 2006, the Appalachian Region spent 1.85 quadrillion Btu (quads) in the residential sector; 1.47 quadrillion Btu in the commercial sector; 2.62 quadrillion Btu in the industrial sector; and 2.16 quadrillion Btu in the transportation sector (Figure 1.4). Compared with the nation as a whole, Appalachia consumes slightly more of its energy on residential and commercial uses and less in the industrial and transportation sectors. *Energizing Appalachia* (ARC, 2006, p. 8) suggests that the significant difference in the residential sector ―probably reflects the lower efficiency of the Region's housing stock." It may also be a function of the Region's dual heating and cooling seasons, which requires either space heating or air conditioning most months of the year to maintain indoor comfort.

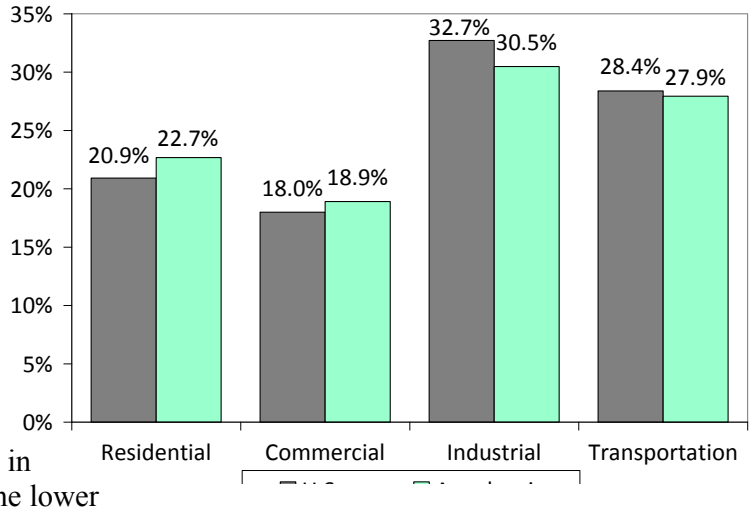

Figure 1.4 Energy Consumption Shares in the U.S. and Appalachia by End-Use Sectors, 2006
(EIA, 2008a)

The energy consumption of each sector is forecast to increase over the next 25 years, expanding consumption in 2030 to 2.47 quadrillion Btu (24 percent) in the residential sector, 2.26 quadrillion Btu (22 percent) in the commercial sector, 2.87 quadrillion Btu (28 percent) in the industrial sector, and 2.54 quadrillion Btu (25 percent) in the transportation sector (Table 1.1).

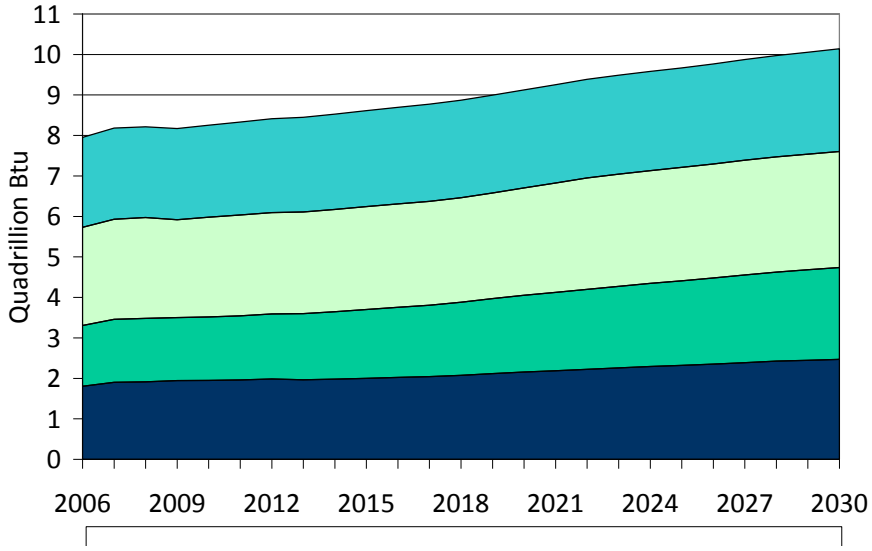

Figure 1.5 Energy Consumption Projections by Sector of the Appalachian Region, 2006-2030
(EIA, 2008a)

Appalachia largely depends on coal to generate electric power, as does the United States. Because coal mining is a major industry in the Region and Appalachia is an exporter of electric power, coal contributes 57 percent of the energy consumption for electric power generation. Compared to the nation as a whole, Appalachia depends more on coal and nuclear and less on natural gas and renewable sources (Figure 1.6).

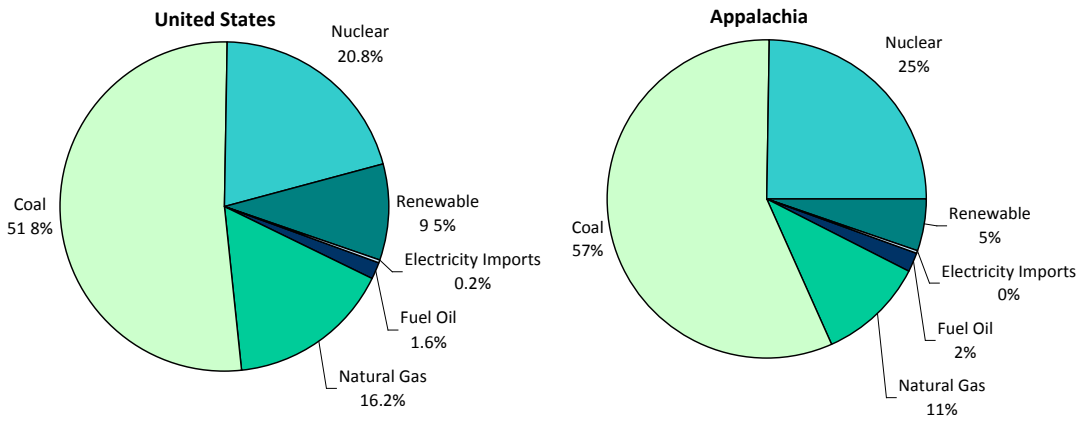

Figure 1.6 Energy Consumption for Electric Power Generation, 2006
(EIA, 2008a)

Corresponding to the total energy consumption projections, EIA projects that Appalachia will increase its share of coal consumption for electricity generation between 2020 and 2030 (Figure 1.7).

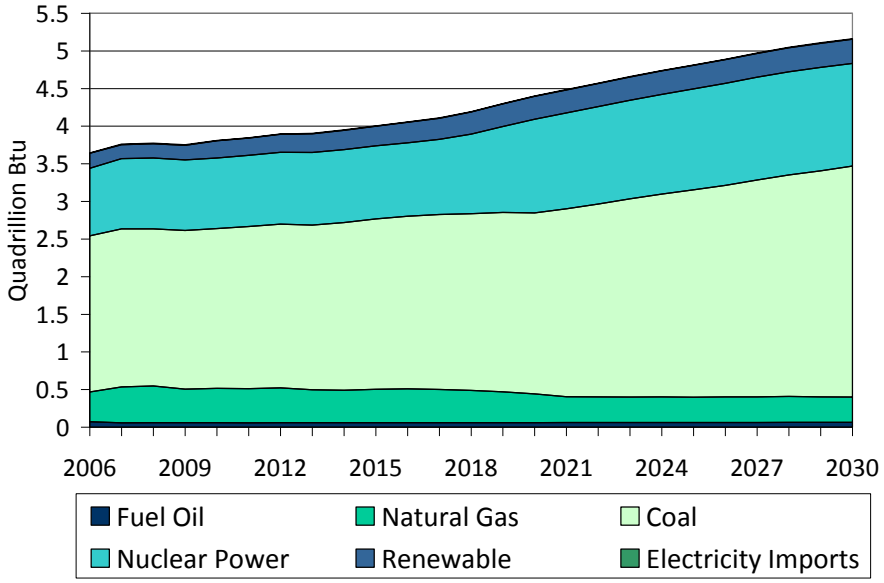

Figure 1.7 Energy Consumption for Electric Power Generation in the Appalachian Region, 2006-2030
(EIA, 2008a)

1.2.2.3 Energy Prices

Energy in Appalachia is relatively cheap, and EIA forecasts that this comparative advantage will continue through 2030 (Table 1.3). Appalachia's prices for motor gasoline, distillate fuel oil, natural gas, coal, and electricity are all lower than U.S. averages. The only exception is liquefied petroleum gases (LPG), which cost more in Appalachia than on average in the United States. This high price may explain why LPG usage in Appalachia constitutes such a small fraction of the Region's energy budget (0.8 percent vs. 2.7 percent for the nation).

An analysis by the Center for Business and Economic Research (2006) suggests that residential and commercial consumers in this Region are fairly insensitive in the short-run to increases in the price of electricity. This lack of responsiveness to electricity price changes, which is similar to behavior in other Regions of the country, suggests the magnitude of policy change needed to alter the consumption of energy. With price elasticities of -0.15 and -0.17, the CBER results indicated that residential and commercial users in Appalachia would need to experience a doubling of electricity prices in order to produce a 15 to 17 percent reduction in electricity consumption. If this price insensitivity applies across all energy sources, which is likely, strong policy interventions will be needed to promote energy-efficient purchases and practices. The good news is that smart policies can, indeed, get the job done (Brown, et al, 2001; Geller et al., 2006). And it is this perspective that we actively explore in the analysis that follows.

Table 1.3 Average Energy Prices to All Users in Appalachia and the United States (in 2006 dollars per million Btu)
(EIA, 2008a)

Source	The United States				Appalachia			
	2006	2013	2020	2030	2006	2013	2020	2030
Liquefied Petroleum Gases	20.35	18.61	18.59	19.82	17.39	18.44	18.61	20.10
Motor Gasoline	21.06	19.51	19.64	20.37	15.70	14.73	15.11	16.37
Distillate Fuel Oil	18.56	17.07	17.20	18.74	13.74	13.10	13.33	14.92
Natural Gas	9.22	8.06	7.98	9.36	7.75	6.65	6.78	8.05
Metallurgical Coal	3.54	3.75	3.42	3.60	2.49	2.72	2.53	2.77
Electricity	26.10	25.40	25.23	25.93	18.39	18.94	19.13	20.16

1.2.2.4 Carbon Footprint

When the slightly greater intensity of energy consumption in Appalachia is compounded by the coal-intensity of the Region's electricity production and its lower-than-average use of natural gas, the Region's carbon footprint expands well beyond the national average. Energy use in Appalachia is

estimated to have contributed about 480 million metric tons of carbon dioxide emissions in 2006, based on all energy consumption across all sectors: residential, commercial, industrial, and transportation. These emissions are expected to grow to about 600 million metric tons by 2030.[4] This translates to about 20.2 metric tons of carbon dioxide per person in 2006 (or 5.5 metric tons of carbon), which is forecast to increase to 21 metric tons per person in 2030. In comparison, the U.S. carbon footprint was 19.6 metric tons of carbon dioxide in 2006, declining to an estimated 18.7 metric tons in 2030.

A recent study by Brown, Southworth and Sarzynski (2008) estimated the per capita carbon footprint of the nation‘s largest 100 metropolitan areas. Seventeen of these metro areas lie either entirely within the Appalachian Region or span the metro area‘s boundary. (Figure 1.8) The average carbon footprint of these seventeen metropolitan areas exceeds the national average by approximately 25 percent. Thus, from a climate policy perspective, the Appalachian Region is more vulnerable to the costs associated with any national climate policy, compared with most areas of the country.

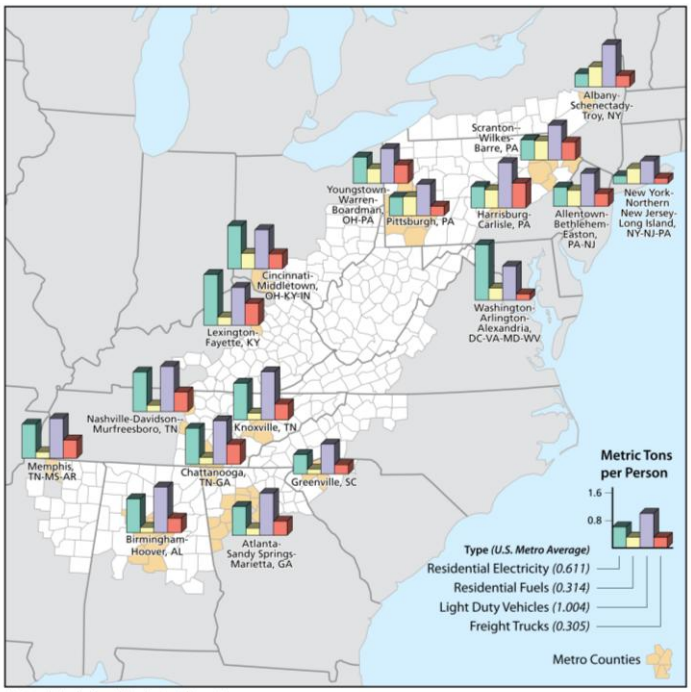

Figure 1.8 Carbon Footprints of 17 Metropolitan Areas in (or Surrounding) the Appalachian Region, 2005*
(Brown, Southworth, and Sarzynski, 2008)

*Carbon footprint refers to the metric tons of carbon emissions per capita from the consumption of residential electricity, residential fuels, the energy consumed by light duty vehicles, and the fuels used by freight trucks.

[4] These numbers are from this study‘s population weighted aggregate Appalachian forecast based on the *AEO* 2008 (EIA, 2008a).

1.3 STRUCTURE OF REPORT

This report is organized into eight chapters followed by references and numerous appendices. The chapters can be grouped into four sections:

Methodology and Policy Analysis (Chapter 2): Provides a broad overview of the methodology used in the policy analysis and energy-efficiency resource assessments. This chapter also outlines the policy bundles modeled in the analysis and describes the alternative future scenarios that could shape their influence. In addition to the ―business-as-usual" forecast, these scenarios include the ―region-at-risk" and ―high-tech-investment-boost" scenarios.

Energy-Efficiency Resource Assessments (Chapters 3-6): Estimates the total potential for cost-effective efficiency in each of the Region's major sectors: residential, commercial, industrial, and transportation sectors. These assessments begin with a description of energy consumption in the Region and the energy-efficiency levels assumed in the ―business-as-usual" forecast. It then describes each of the policy bundles, the methodology used to analyze them, and the estimates of energy savings and costs. The chapters end by describing the estimated cost-effectiveness of each policy bundle, both individually and for the sector as a whole.

Economy Wide Results (Chapter 7): Estimates the economy-wide engineering and economic results. In addition to presenting the economy-wide cost-effectiveness tests, this chapter characterizes the employment impacts and workforce requirements of each scenario.

Summary and Conclusions (Chapter 8): The report ends with a discussion of its findings. This includes a comparison of the results with other assessments of cost-effective energy efficiency. It also discusses the package of policy bundles in terms of its political feasibility.

These chapters are supplemented by detailed appendices that provide additional explanation, assumptions and analysis details. Appendix A summarizes the Region-wide inventory of energy-efficiency policies. Appendices B through E provide additional information about the methodology used to analyze each sector. Appendix F provides further information on the baseline analysis and the use of the *Dynamic Energy Efficiency Policy Evaluation Routine* (DEEPER) model to integrate the sector-specific results into a macroeconomic evaluation of the policies as they might impact the Region. Finally Appendix G presents a sensitivity analysis of the cost-effectiveness estimates, including an assessment of higher fossil fuel prices that could arise in a carbon-constrained future.