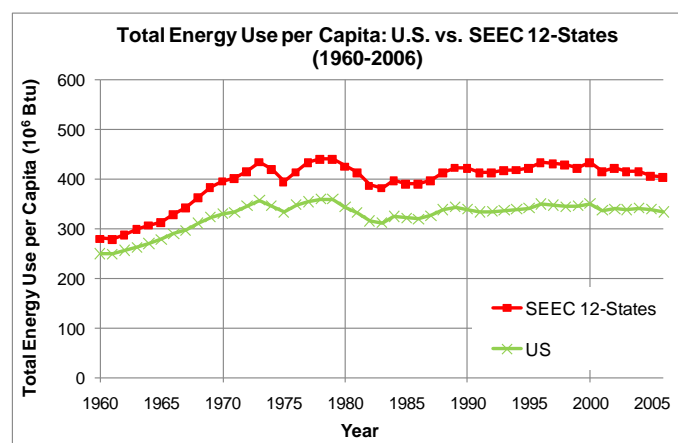


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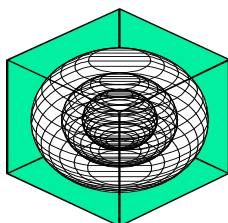
REGIONAL ENERGY BASELINES AND MEASUREMENT AND VERIFICATION PROTOCOLS

Subtask 3.1 for the Southern Energy Efficiency Center
Cooperative Agreement #: DE-PS26-07NT43185



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By:

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EXECUTIVE SUMMARY

The Southern Energy Efficiency Center (SEEC) was established to substantially increase the deployment of high-performance “beyond-code” buildings across the southern region of the U.S. It is funded by the U.S. Department of Energy (DOE) Building Technologies Program, and administered by the National Energy Technology Laboratory. The goal of the first 18-month phase was to address efficiency goals of states, utilities, and various energy-efficiency programs. In order to achieve this goal, the project efforts included defining the baseline energy patterns within the project region, as well as the measurement and verification (M&V) protocols for use in determining the efficiency improvements SEEC, state and USDOE efforts with respect to that baseline. This work is defined under the SEEC Subtask 3.1 *Define Regional Baselines and Measurement & Verification Protocols*. This report presents preliminary deliverables of this subtask developed and documented by the Energy Systems Laboratory (ESL) for use by the SEEC member state region.

The primary goal of this subtask is to provide the state energy offices with a comparison tool of energy use either by total or per-capita. This tool is expected to allow the state energy offices to compare their energy use pattern against other states’ and the national average energy use by end-use sector. In addition, they can use this tool for a comparison of energy use within their states by end-use and by fuel-source. Another goal of this subtask is to demonstrate the usability of public-available data such as the U.S. Department of Energy’s Energy Information Agency (DOE EIA) data sets and the U.S. Census Bureau data sets. This approach has been successfully demonstrated by the ESL as part of the Comptroller of Public Accounts and the State Energy Conservation Office report on Texas Energy Future.

To define the baseline energy patterns within the SEEC 12-state region (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia), the raw data have been downloaded from the following websites: the U.S. DOE EIA website¹; and the U.S. Census Bureau website². Appendix A and B present the detailed information of data sets that have been used for this subtask, including the source, selected data codes, and term definitions.

The stated deliverables for the SEEC Subtask 3.1 consists of four parts:

- Energy use per capita ranked by state for 2006 (latest year data available);
- Historical energy use per capita for the SEEC 12-state during 1960-2006;
- Energy use and energy use per capita by end-use sector and fuel source during 1960-2006 for the U.S. and each state; and
- Recommended measurement and verification (M&V) protocols - ASHRAE/CIBSE/USGBC Performance Measurement Protocols (PMP) for Commercial Buildings.

Limited preliminary analysis of the data was made since it was not a project goal. The data provides the basis by which extensive state by state analysis can begin. In addition, the recommended measurement and verification (M&V) protocols for an individual building or facility, ASHRAE/CIBSE/USGBC Performance Measurement Protocols (PMP) for Commercial Buildings, can be used as a bottom-up approach for energy efficiency improvements of buildings within the SEEC 12-state region.

¹ U.S. DOE, EIA. 2008. *Consumption, Price, and Expenditure Estimates through 2006: Complete Data Files, All States and All Years*, State Energy Data System (SEDS), Energy Information Administration, U.S. Department of Energy, Retrieved from <http://www.eia.doe.gov/emeu/states/seds.html> (accessed February 2, 2009).

² U.S. Census Bureau. 2008. *Annual Population Estimates 2000 to 2008: Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2008*, National and State Population Estimates, U.S. Census Bureau, Retrieved from <http://www.census.gov/popest/states/NST-ann-est.html> (accessed February 2, 2009).

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1 INTRODUCTION

The Southern Energy Efficiency Center (SEEC) was established to substantially increase the deployment of high-performance “beyond-code” buildings across the southern region of the U.S. It is funded by the U.S. Department of Energy (DOE) Building Technologies Program, and administered by the National Energy Technology Laboratory. The goal of the first 18-month phase was to address efficiency goals of states, utilities, and various energy-efficiency programs. In order to achieve this goal, the project efforts included defining the baseline energy patterns within the project region, as well as the measurement and verification (M&V) protocols for use in determining the efficiency improvements SEEC, state and USDOE efforts with respect to that baseline. This work is defined under the SEEC Subtask 3.1 *Define Regional Baselines and Measurement & Verification Protocols*. This report presents preliminary deliverables of this subtask developed and documented by the Energy Systems Laboratory (ESL) for use by the SEEC member state region.

The primary goal of this subtask is to provide the state energy offices with a comparison tool of energy use either by total or per-capita. This tool is expected to allow the state energy offices to compare their energy use pattern against other states’ and the national average energy use by end-use sector. In addition, they can use this tool for a comparison of energy use within their states by end-use and by fuel-source. Another goal of this subtask is to demonstrate the usability of public-available data such as the U.S. Department of Energy’s Energy Information Agency (DOE EIA) data sets and the U.S. Census Bureau data sets. This approach has been successfully demonstrated by ESL as part of the Comptroller of Public Accounts and the State Energy Conservation Office report on Texas Energy Future.

Limited preliminary analysis of the data was made since it was not a project goal. The data provides the basis by which extensive state by state analysis can begin. In addition, the recommended measurement and verification (M&V) protocols for an individual building or facility, ASHRAE/CIBSE/USGBC Performance Measurement Protocols (PMP) for Commercial Buildings, can be used as a bottom-up approach for energy efficiency improvements of buildings within the SEEC 12-state region.

1.1 Statement of Project Objectives for the Southern Energy Efficiency Center (SEEC)

This report presents the ESL’s work to develop preliminary deliverables for the SEEC Subtask 3.1. These deliverables are intended to cover the SEEC’s Statement of Project Objectives for the Subtask 3.1 outlined below:

- Define baseline energy patterns within the SEEC 12-state region; and
- Define measurement and verification (M&V) protocols for use in determining the efficiency improvements with respect to that baseline.

1.2 Preliminary Deliverables for the SEEC Subtask 3.1

The stated deliverables for the SEEC Subtask 3.1 consists of four parts:

- Energy use per capita ranked by state for 2006 (latest year data available);
- Historical energy use per capita for the SEEC 12-state during 1960-2006;
- Energy use and energy use per capita by end-use sector and fuel source during 1960-2006 for the U.S. and each state; and
- Recommended measurement and verification (M&V) protocols - ASHRAE/CIBSE/USGBC Performance Measurement Protocols (PMP) for Commercial Buildings.

To define the baseline energy patterns within the SEEC 12-state region (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia), the raw data have been downloaded from the following websites: the U.S. DOE EIA website³; and the U.S. Census Bureau website⁴. Appendix A and B presents the detailed information of data sets that have been used for this subtask, including the source, selected data codes, and term definitions.

Section 2 presents the charts showing the energy use per capita ranked by state for 2006, including total use and use by end-use sector. Section 3 presents the charts showing the historical energy use per capita for the SEEC 12-state during 1960-2006, including total use and use by end-use sector. Section 4 presents the charts showing the energy use and energy use per capita by end-use sector and fuel source during 1960-2006 for the U.S. and each state. And lastly, Section 5 summarizes the energy section of the ASHRAE/CIBSE/USGBC Performance Measurement Protocols (PMP) for Commercial Buildings.

³ U.S. DOE, EIA. 2008. *op. cit.*

⁴ U.S. Census Bureau. 2008. *op. cit.*

2 2006 ENERGY USE PER CAPITA, RANKED BY STATE

2.1 Overview

This section covers the energy use per capita of the 50 states and the District of Columbia for 2006, including total energy use per capita (Figure 2.2.1) and energy use per capita by end-use sector (Figure 2.3.1 to Figure 2.6.1): electric power, residential, commercial, residential plus commercial, transportation, and industrial sector. Two different scales were selected and used to display data for the purpose of a comparison: 1,200 million Btu for the charts of total and electric power sector and 600 million Btu for the charts of other sectors, including residential, commercial, residential plus commercial, transportation, and industrial sector.

Each state's energy use per capita is ranked by state with the U.S. average energy use per capita. The green bar indicates the U.S. average energy use per capita and is displayed with a dotted green line for a better comparison. The 12 red bars indicate each of SEEC 12-state's energy use per capita while the 39 blue bars are for the other 38 states and the District of Columbia.

2.2 Total Energy Use per Capita, Ranked by State (2006)

Figure 2.2.1 shows the total energy use per capita of the 50 states and the District of Columbia for 2006. The U.S. average was 334 million Btu per capita. Ten of the SEEC 12-states had higher total energy use per capita than the U.S. average, although two of them had a similar value with the U.S. average. Only two states, North Carolina and Florida, had lower values than the U.S. average.

Alaska had the highest total energy use per capita for 2006 with 1,114 million Btu, whereas New York had the lowest value with 203 million Btu. Alaska's high energy intensity is mainly due to its high transportation and industrial energy consumption. This could be partially explained with the dominant industry of Alaskan economy in oil and gas and its low population density. On the contrary, New York's low energy intensity can be explained with its high population density. Wyoming, Louisiana, and North Dakota also have a distinctly high energy use pattern: about 3-5 times more energy per capita than the low energy-intensive states. This could be due to their high transportation and industrial energy consumption and low population density of Wyoming and North Dakota.

Among the SEEC 12-states, Louisiana ranked the highest at 896 million Btu per capita while Florida ranked the lowest at 256 million Btu per capita. The second highest was Texas at 503 million Btu per capita, and the second lowest was North Carolina at 301 million Btu per capita. The high rank of Louisiana and Texas is mainly due to their high industrial energy consumption. Louisiana ranked the highest in industrial energy use per capita at 570 million Btu that occupies 64% of total energy use per capita. Texas ranked fifth place at 254 million Btu that represents 50% of total energy use per capita.

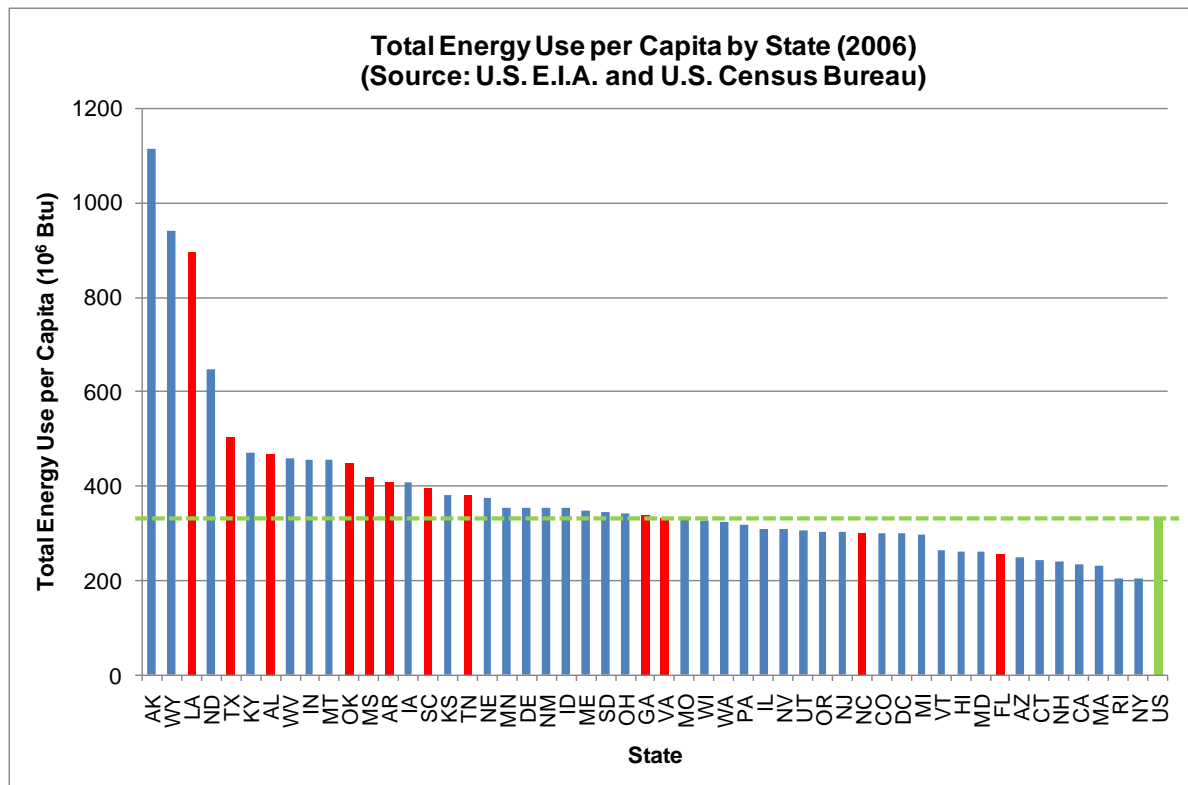


Figure 2.2.1. Total Energy Use per Capita, Ranked by State, 2006.

2.3 Electric Power Energy Use per Capita, Ranked by State (2006)

Figure 2.3.1 shows the electric power energy use per capita of the 50 states and the District of Columbia for the year 2006. The electric power energy use consists of the energy consumed by facilities to generate, transmit and distribute electric energy. The U.S. average was 133 million Btu per capita, and ten of the SEEC 12-states had higher electric power energy use per capita than the U.S. average. Only two states, Florida and Virginia, had lower values than the U.S. average.

Wyoming had the highest electric power energy use per capita for 2006 with 921 million Btu, whereas the District of Columbia had the lowest value with 2.3 million Btu. Wyoming's high electric power energy intensity, in spite of its lowest population density in the U.S., could be due to the massive power facilities in Wyoming to provide electricity to the western United States. On the contrary, the District of Columbia showed abnormally low electric power energy intensity because D.C. relies on imported electricity from the surrounding states. It must be noted that the amount of electricity produced in the state is sometimes different from the amount consumed in the state. North Dakota and West Virginia, as interstate exporters of electricity, also showed distinctly high electric power energy intensity: about 4 times more energy per capita than the U.S. average. Electric use per capita in each state warrants closer investigation into how it is reported to EIA with USDOE.

Among the SEEC 12-states, Alabama ranked the highest at 296 million Btu per capita while Virginia ranked the lowest at 97 million Btu per capita. The second highest was South Carolina at 232 million Btu per capita, and the second lowest was Florida at 114 million Btu per capita. Although the top two states, Alabama and South Carolina, export surplus energy to other states, they are also big electricity energy consumers. Among the 50 states and the District of Columbia, Alabama and South Carolina ranked in third and fifth place, respectively, in total electricity energy per capita consumed within the state.

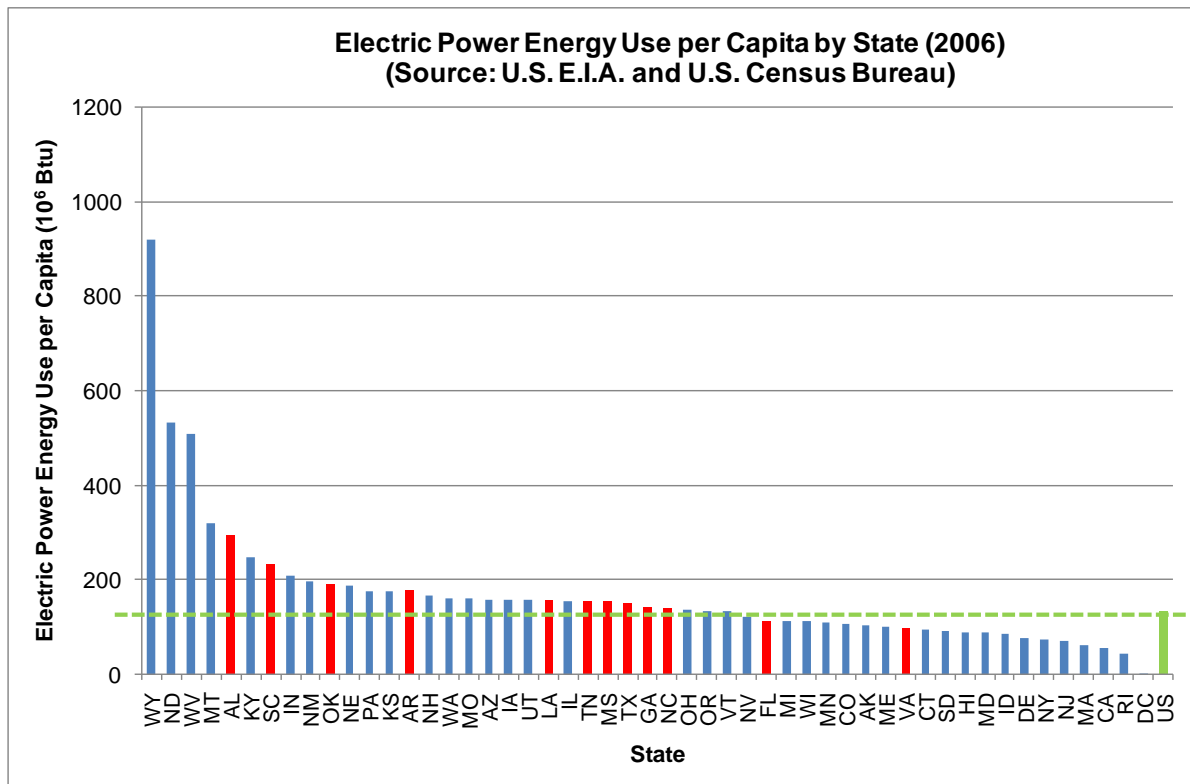


Figure 2.3.1. Energy Use per Capita by the Electric Power Sector, Ranked by State, 2006.

2.4 Residential and Commercial Energy Use per Capita, Ranked by State (2006)

Figure 2.4.1 and Figure 2.4.2, respectively, show the residential and the commercial energy use per capita of the 50 states and the District of Columbia for the year 2006. Figure 2.4.3 shows the combined residential and commercial per capita energy use that can be regarded as the entire building sector's per capita energy use. The commercial energy use consists of the energy consumed by many different building types, including businesses, institutions, and organizations that provide services. For the purpose of a comparison and clarity, a different scale was used in Sections 2.4 to 2.6.

The U.S. average was 70 million Btu per capita for the residential sector and 59 million Btu per capita for the commercial sector. For both residential and commercial building sectors, the variation between states was relatively small compared with other end-use sectors. Only Texas had a lower residential energy use per capita than the U.S. average while six of the SEEC 12-states, including South Carolina, Florida, Georgia, Texas, Arkansas, and Mississippi, had lower commercial energy use per capita than the U.S. average.

Although 11 SEEC states showed higher per capita residential energy use than the U.S. average, the variation of residential energy intensity between the states was relatively small except for the two least energy-intensive states of California and Hawaii. For the commercial buildings sector, the variation between states was relatively small except for four top-ranking states including D.C., Wyoming, Alaska, and North Dakota and two low-ranking states of California and Hawaii. A similar pattern was found in the combined residential and commercial per capita energy use. Only Texas showed lower energy intensity than the U.S. average among the SEEC 12-states. It is noticeable that California had far less combined residential and commercial per capita use than the other states and the US average. This could be partly because of their mild climate, and partly because of their earliest adoption of various energy policies and incentives.

All of the SEEC 12-states' per capita residential energy use ranges between 87 million Btu per capita (Alabama) and 68 million Btu per capita (Texas). For the commercial sector, Virginia ranked the highest at 75 million Btu per capita while Mississippi ranked the lowest at 56 million Btu per capita. The combined residential and commercial per capita energy use of the SEEC 12-states ranges between 153 million Btu per capita (Virginia) and 126 million Btu per capita (Texas).

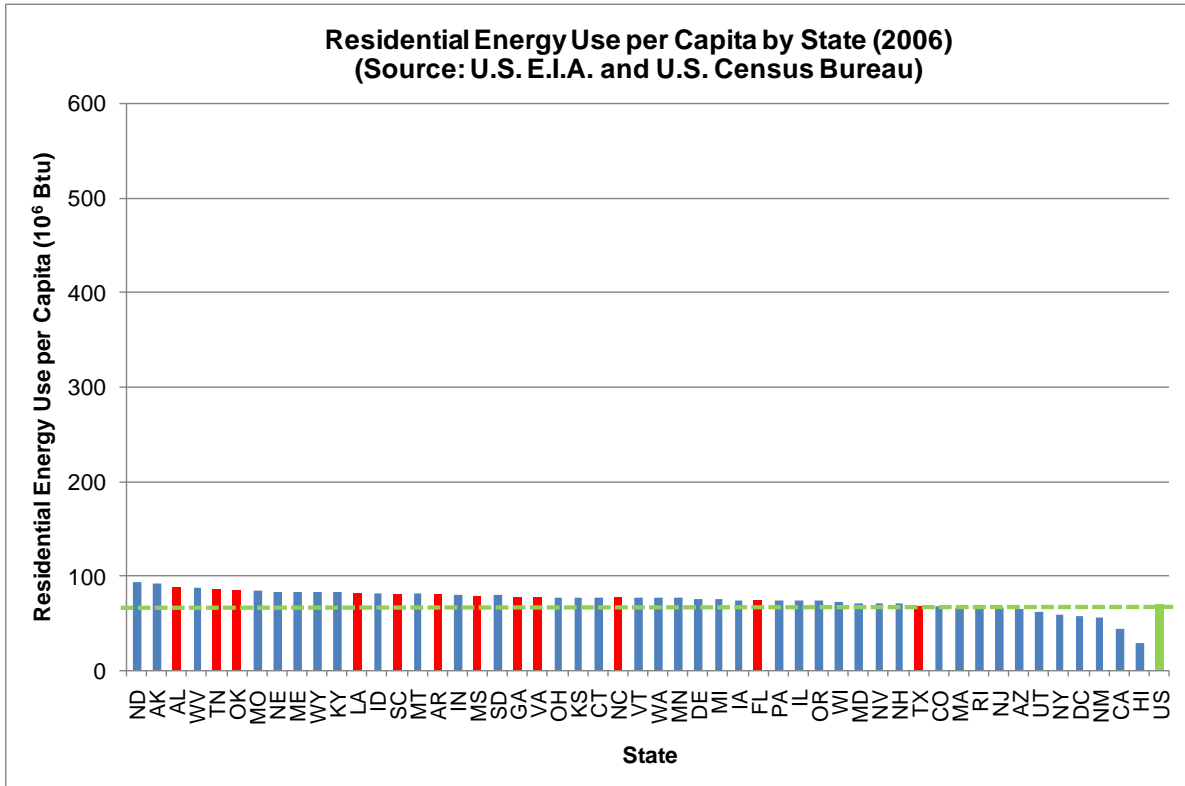


Figure 2.4.1 Energy Use per Capita by the Residential Sector, Ranked by State, 2006.

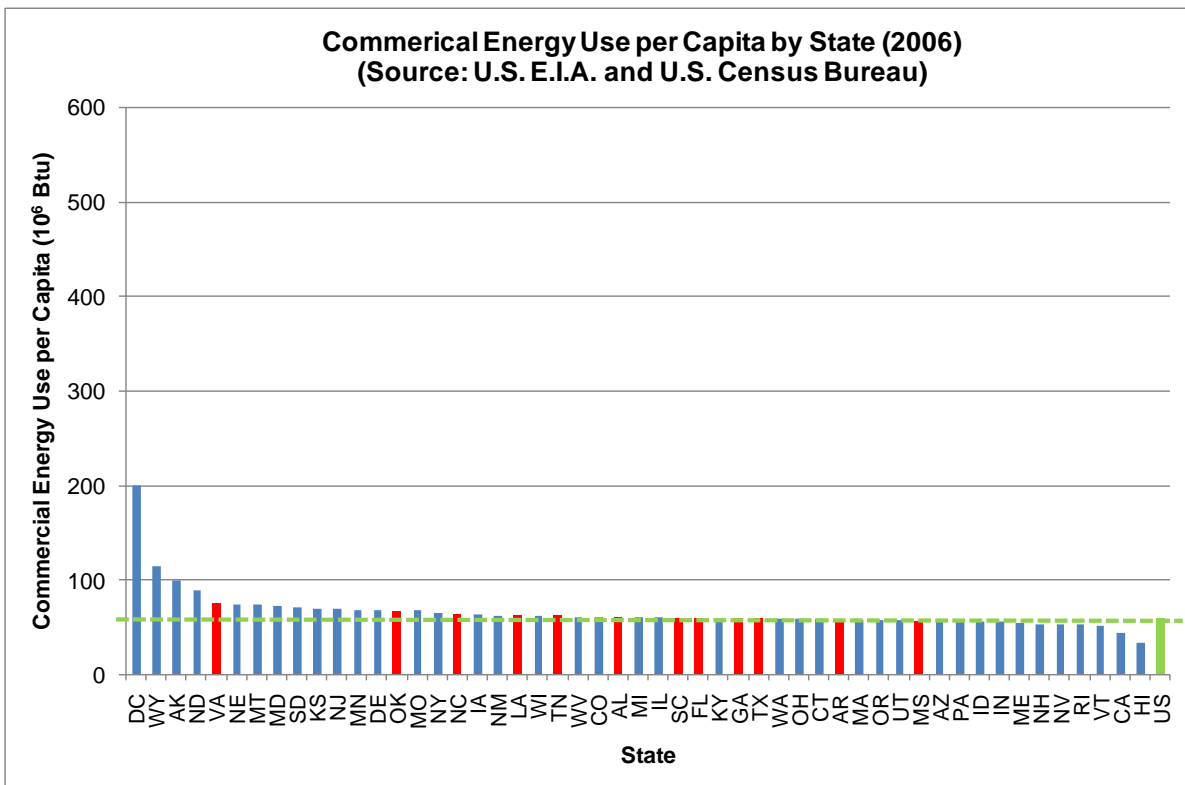


Figure 2.4.2. Energy Use per Capita by the Commercial Sector, Ranked by State, 2006.

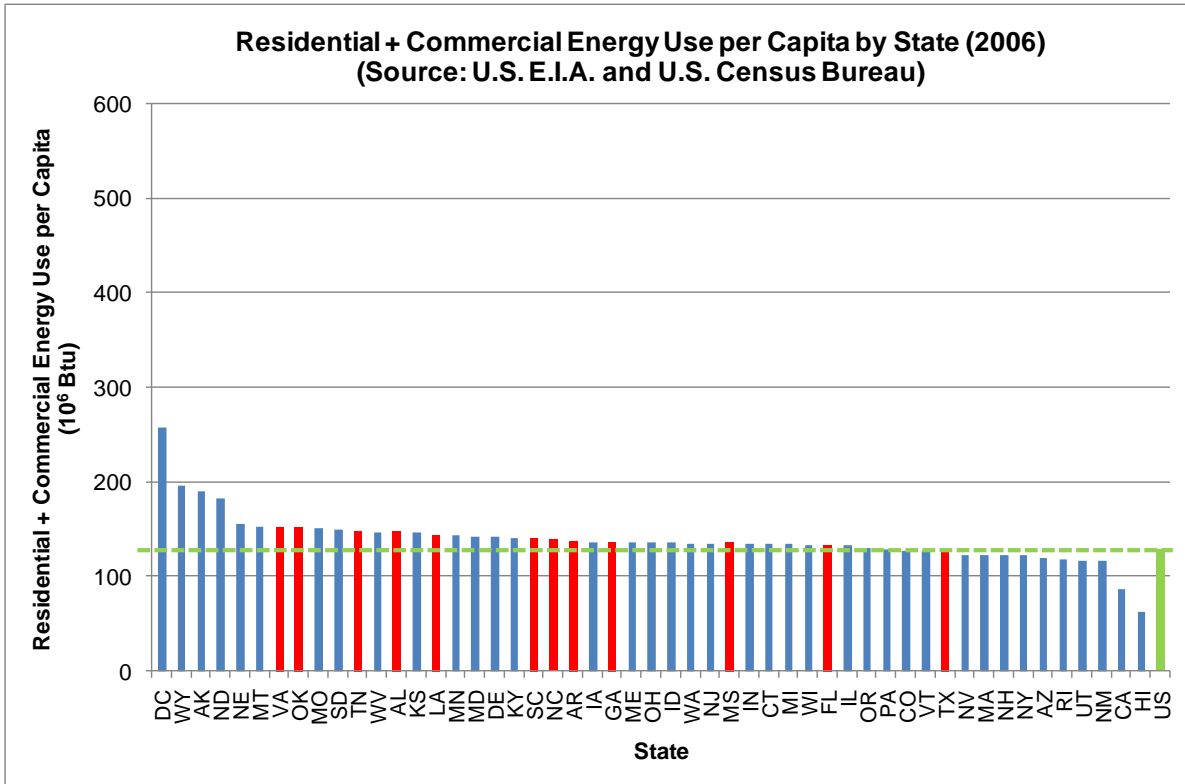


Figure 2.4.3. Energy Use per Capita by the Residential and Commercial Sector, Ranked by State, 2006.

2.5 Transportation Energy Use per Capita, Ranked by State (2006)

Figure 2.5.1 shows the transportation energy use per capita of the 50 states and the District of Columbia for 2006. The U.S. average was 97 million Btu per capita. Ten of the SEEC 12-states had higher transportation energy use per capita than the U.S. average. Only two states, Florida and North Carolina, had lower value than the U.S. average.

Alaska had the highest transportation energy use per capita for 2006 with 393 million Btu, whereas the District of Columbia had the lowest value with 36 million Btu. Alaska's high transportation energy intensity may be partly because of its high aviation fuel consumption, and its high industrial energy consumption. Similarly, the District of Columbia's very low transportation energy intensity can be explained with its high availability and usage of public transportation. A similar result can be found in New York that ranked in the second lowest place due to its public transportation.

Among the SEEC 12-states, Louisiana ranked the highest at 182 million Btu per capita, while North Carolina ranked last at 84 million Btu per capita. The second highest was Mississippi at 130 million Btu per capita, and the second lowest was Florida at 90 million Btu per capita. The high transportation energy intensity of the top four states, Louisiana, Mississippi, Oklahoma, and Texas, may explain their high industrial energy consumption.

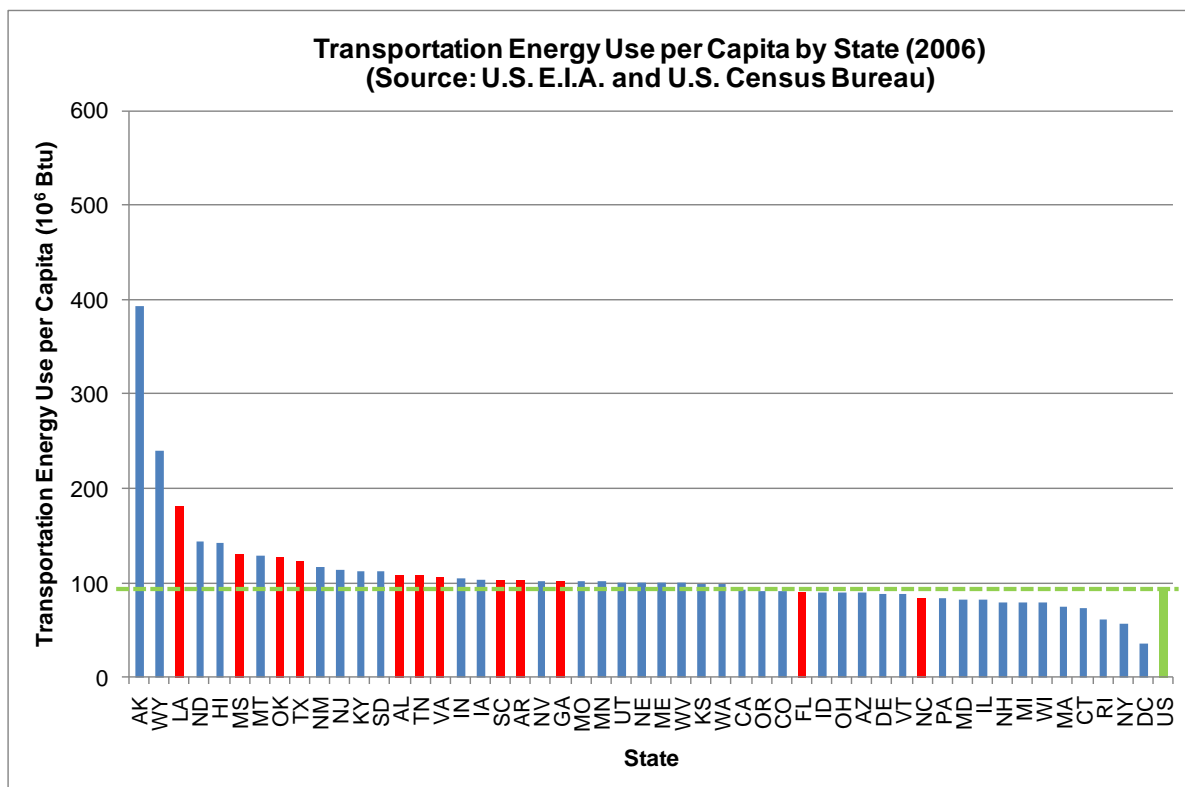


Figure 2.5.1. Energy Use per Capita by the Transportation Sector, Ranked by State, 2006.

2.6 Industrial Energy Use per Capita, Ranked by State (2006)

Figure 2.6.1 shows the industrial energy use per capita of the 50 states and the District of Columbia for the year 2006. The U.S. average was 108 million Btu per capita, and eight of the SEEC 12-states had a higher industrial energy use per capita than the U.S. average. Whereas, four states, including Georgia, North Carolina, Virginia and Florida, had a lower value than the U.S. average.

The variation of industrial energy intensity between states was very high compared with other end-use sectors. Louisiana had the highest industrial energy use per capita for 2006 with 570 million Btu, whereas the District of Columbia had the lowest value with 6.1 million Btu. Alaska, Wyoming, North Dakota and Texas also showed distinctly high industrial energy intensity, more than twice the U.S. average.

Among the SEEC 12-states, Louisiana ranked first place with the highest industrial energy intensity among the 50 states, while Florida ranked last at 32 million Btu per capita. The second highest was Texas at 254 million Btu per capita, and the second lowest was Virginia at 75 million Btu per capita. The high industrial energy use per capita is mainly because of their high energy-intensive industrial activities, including manufacturing, agriculture, and mining. Due to the large amount of energy consumption by the industrial sector, industrial energy intensity can be regarded as the most significant determinant of total energy use pattern of each state. The ranking of total energy use per capita generally matched closely with the ranking of industrial energy use per capita.

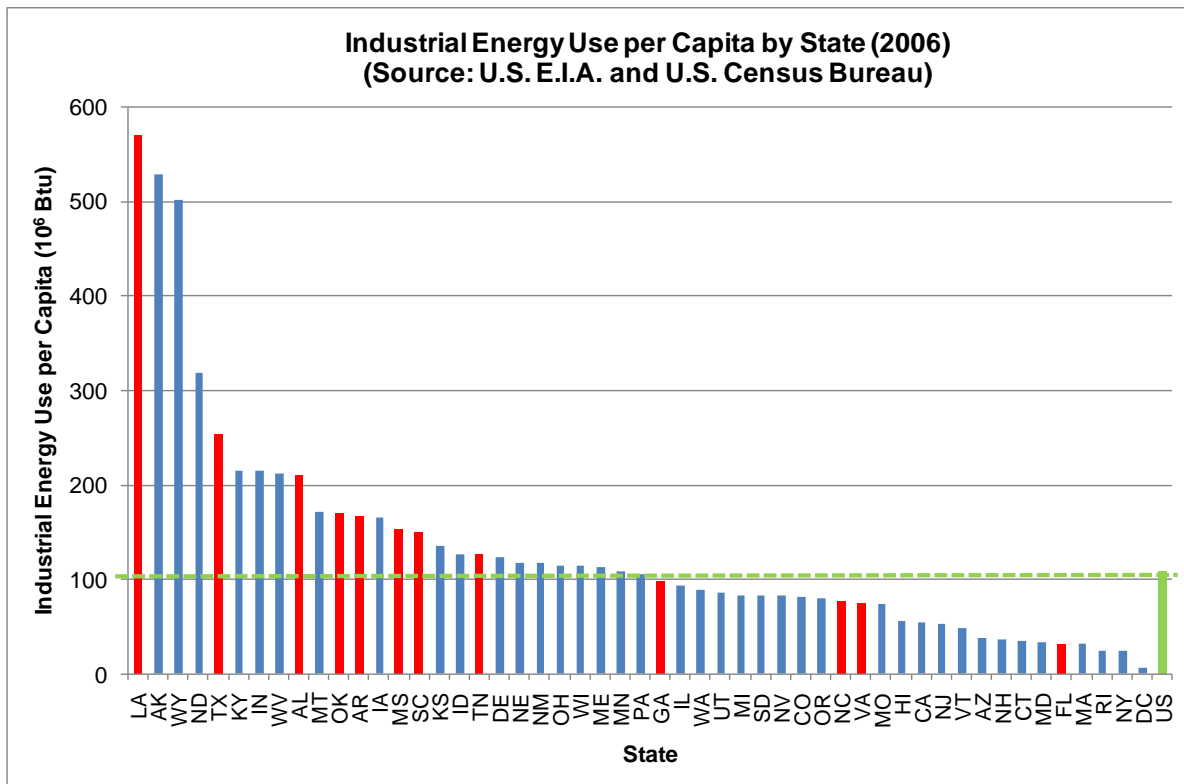


Figure 2.6.1. Energy Use per Capita by the Industrial Sector, Ranked by State, 2006.

3 HISTORICAL ENERGY USE PER CAPITA FOR THE SEEC 12-STATES DURING 1960-2006

3.1 Overview

This section covers the historical energy use per capita of the SEEC 12-states during the period of 1960 to 2006, including total energy use per capita (Figure 3.2.1) and energy use per capita by end-use sector (Figure 3.3.1 to Figure 3.6.1): electric power, residential, commercial, residential plus commercial, transportation, and industrial sector. Two different scales were selected and used to display data for the purpose of a comparison. The following scales were used: 1,200 million Btu for the charts of total and industrial sector and 300 million Btu for the charts of other sectors, including residential, commercial, residential plus commercial, transportation, and electric power sector.

Each state's energy use per capita is displayed with the U.S. average energy use per capita which is indicated by the red line. The other 12 lines indicate the historical energy use pattern of each SEEC 12-states – Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia.

3.2 Total Energy Use per Capita for the SEEC 12-States during 1960-2006

Figure 3.2.1 shows the total energy use per capita of the SEEC 12-states during the period of 1960 to 2006. Louisiana ranked the highest, and the second highest was Texas. This is mainly due to their high industrial energy use per capita. It is noticeable that Texas's total energy use per capita has decreased since 2000, while Louisiana's energy consumption pattern is fluctuating. Florida ranked the lowest, and since the middle of the 1970's, their energy use pattern remained almost flat around 250 million Btu per capita, less than the U.S. average. Except for the above-mentioned three states, the per capita energy use patterns of the other nine states were tightly grouped.

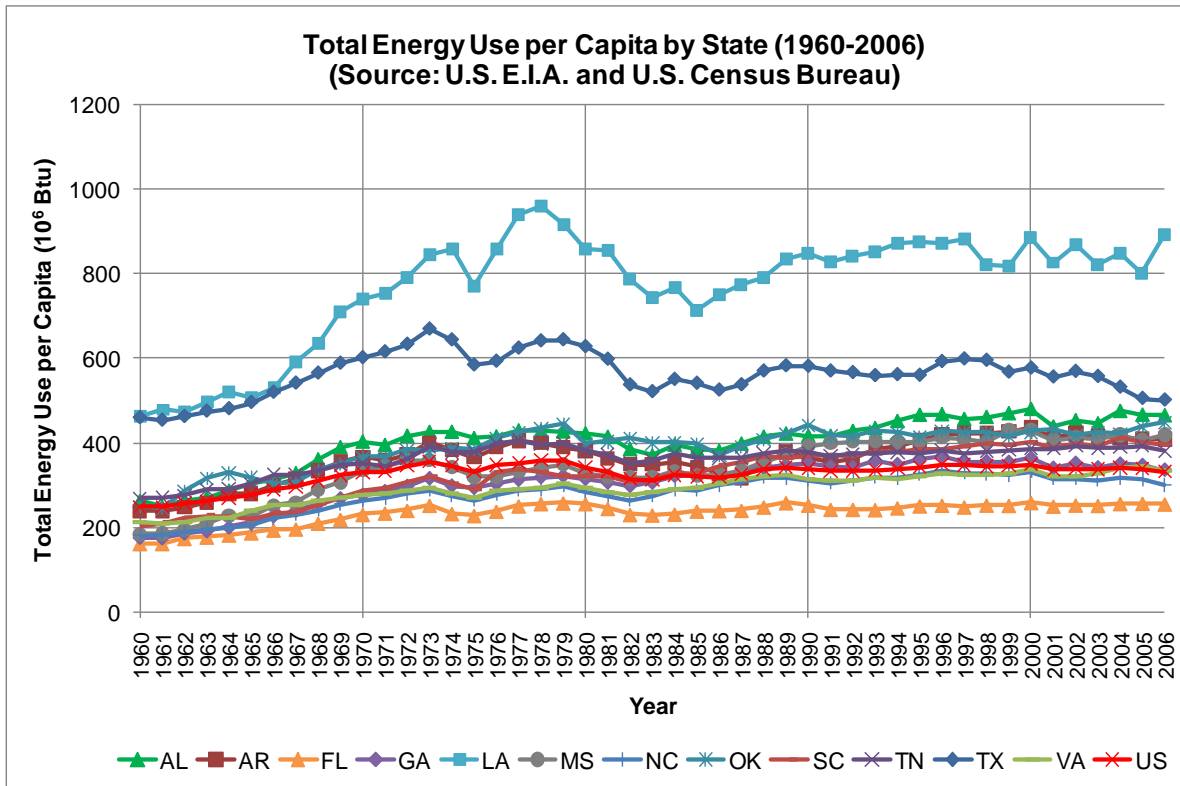


Figure 3.2.1. Total Energy Use per Capita, for the SEEC 12-States during 1960-2006.

3.3 Industrial Energy Use per Capita for the SEEC 12-States during 1960-2006

Figure 3.3.1 shows the industrial energy use per capita of the SEEC 12-states during the period of 1960 to 2006. The historical per capita industrial energy use pattern has parallels with the total energy use per capita addressed in the previous section. Louisiana ranked the highest, and the second highest was Texas. It is noticeable that that Texas's industrial energy use per capita has been decreasing since 2000; while Louisiana's industrial energy consumption pattern is fluctuating. Florida ranked the lowest, and since the 1980's, their industrial energy use pattern remained almost flat around 40 million Btu per capita; that is much less than the U.S. average. Except for the above-mentioned three states, the per capita industrial energy use patterns of the other nine states were tightly grouped.

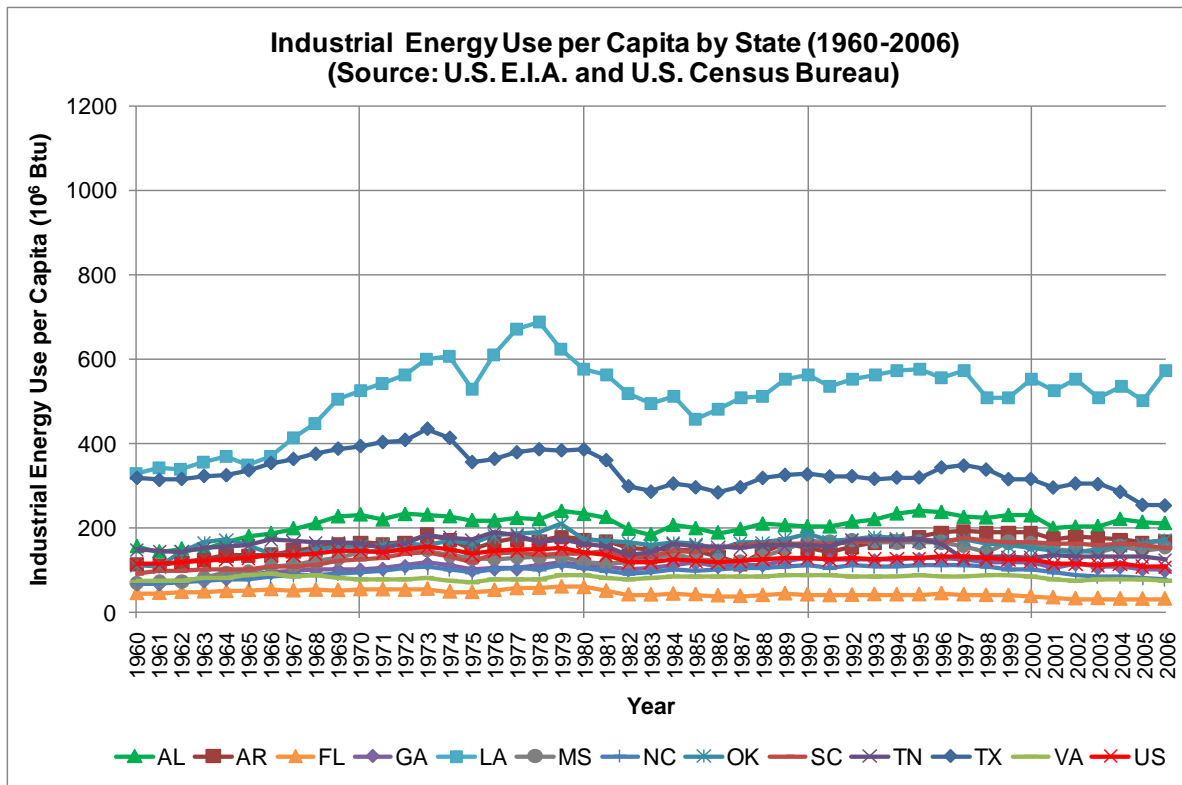


Figure 3.3.1. Energy Use per Capita by the Industrial Sector, for the SEEC 12-States during 1960-2006.

3.4 Residential and Commercial Energy Use per Capita for the SEEC 12-States during 1960-2006

Figure 3.4.1 and Figure 3.4.2, respectively, shows the residential and the commercial energy use per capita of the SEEC 12-states during the period of 1960 to 2006, and Figure 3.4.3 shows the combined residential and commercial per capita energy use that can be regarded as the whole building sector's per capita energy use. The commercial energy use consists of the energy consumed by many different building types, including businesses, institutions, and organizations that provide services. For the purpose of a comparison, a different scale was used in Sections 3.4 to 3.6.

For both residential and commercial, the per capita energy use has been slightly increasing over the years. However, the variation across states was very small compared with other end-use sectors; per capita energy uses of all twelve states were tightly grouped with a range of about 20 million Btu per capita. In 2006, Alabama ranked the highest, and the lowest was Texas. For commercial sector, Virginia ranked the highest, and Mississippi the lowest. Virginia ranked the highest of the combined residential and commercial per capita energy use in 2006. Texas was the lowest among the SEEC 12-states. It is noticeable that Texas' residential energy use per capita has been decreasing since 2000 while Virginia's commercial energy use per capita has been continuously increasing. In addition, abnormal commercial energy use patterns were found in Louisiana and Tennessee. In the late 1970's, Louisiana's commercial energy use per capita was increasing while in the middle 1990's, Tennessee's commercial energy use per capita declined suddenly.

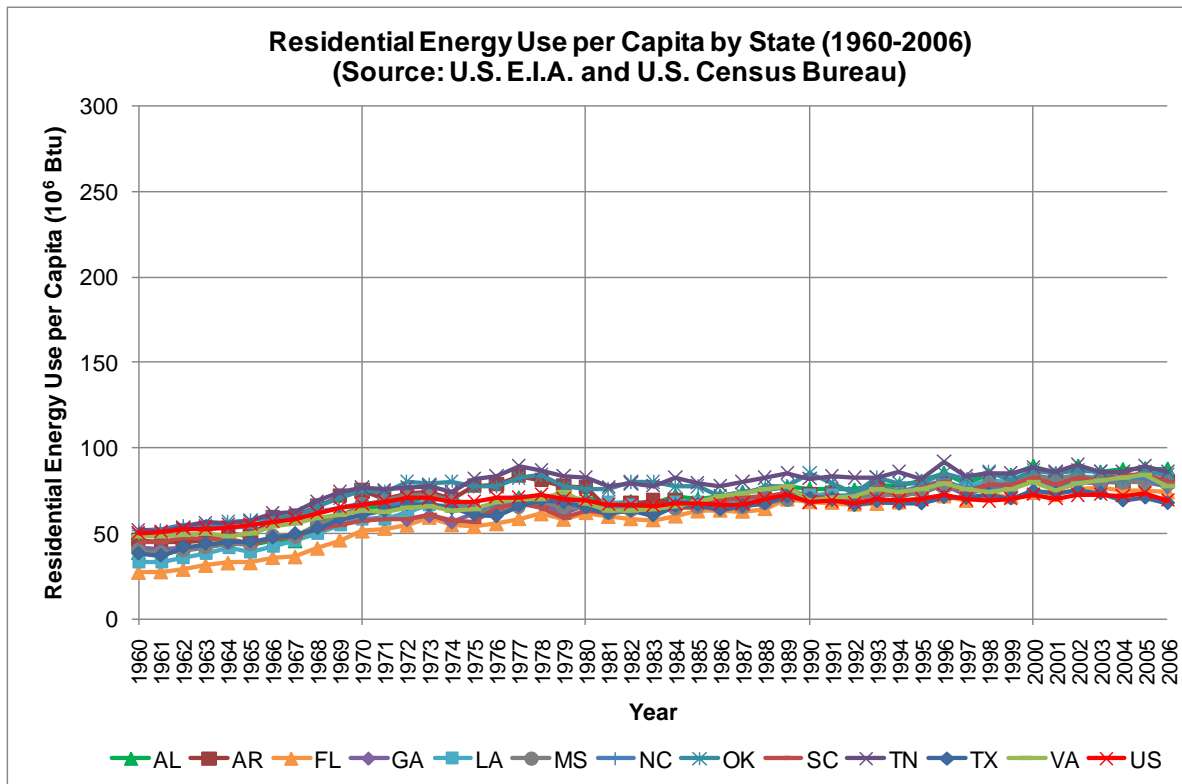


Figure 3.4.1. Energy Use per Capita by the Residential Sector, for the SEEC 12-States during 1960-2006.

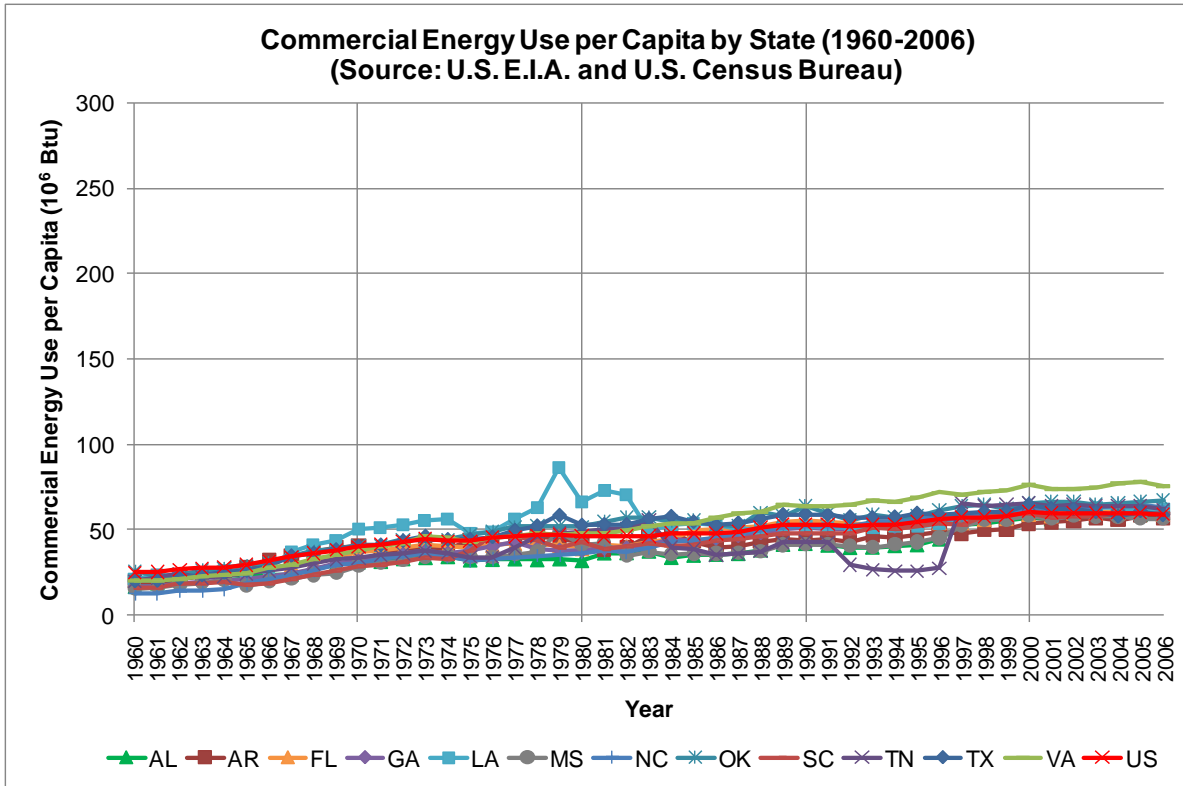


Figure 3.4.2. Energy Use per Capita by the Commercial Sector, for the SEEC 12-States during 1960-2006.

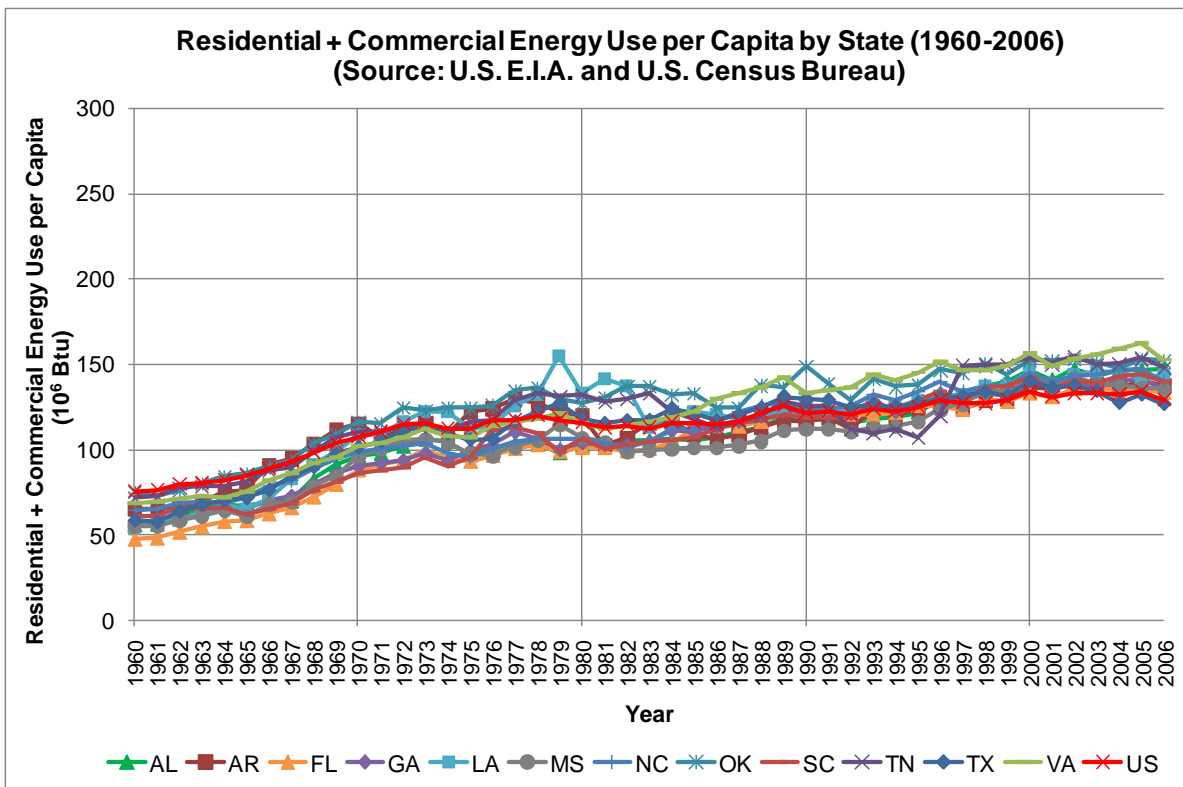


Figure 3.4.3. Energy Use per Capita by the Residential and Commercial Sector, for the SEEC 12-States during 1960-2006.

3.5 Transportation Energy Use per Capita for the SEEC 12-States during 1960-2006

Figure 3.5.1 shows the transportation energy use per capita of the SEEC 12-states during the period of 1960 to 2006. The historical per capita transportation energy use patterns have remained constant since the middle 1970's, except for Louisiana. Louisiana ranked the highest and showed distinctly high transportation energy intensity. This is mainly because of the river bridge traffic to transport oil and gas. The second highest group consists of Mississippi, Texas, and Oklahoma. It is notable that Texas's transportation energy intensity is constant while the transportation energy uses per capita in Mississippi and Oklahoma continued to rise. The lowest group was Florida and North Carolina.

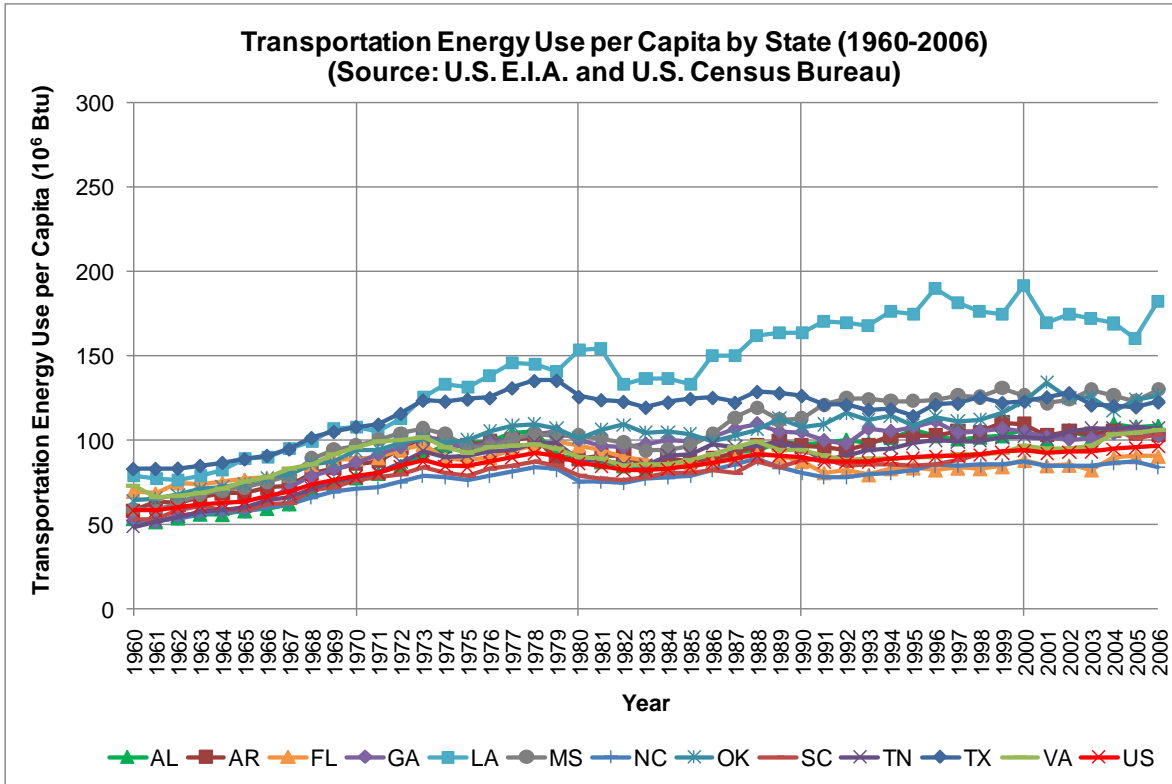


Figure 3.5.1. Energy Use per Capita by the Transportation Sector, for the SEEC 12-States during 1960-2006.

3.6 Electric Power Energy Use per Capita for the SEEC 12-States during 1960-2006

Figure 3.6.1 shows the electric power energy use per capita of the SEEC 12-states during the period of 1960 to 2006. The electric power energy use consists of the energy consumed by facilities to generate, transmit, and distribute electric energy. Thus, it must be noted that the amount of electricity produced in the state is different from that consumed in the state.

The historical per capita electric power energy use per capita has been rising constantly across all twelve states. Alabama ranked the highest at 296 million Btu per capita in 2006 and showed a distinctly high increase in the rate of electric power energy use. The second highest was South Carolina at 232 million Btu per capita in 2006, and the lowest group consists of Florida and North Carolina. Although the top two states, Alabama and South Carolina, export surplus energy to other states, they are also big electricity energy consumers. Among the 50 states and the District of Columbia, Alabama and South Carolina ranked in third and fifth place, respectively, in total electricity energy per capita consumed within the state.

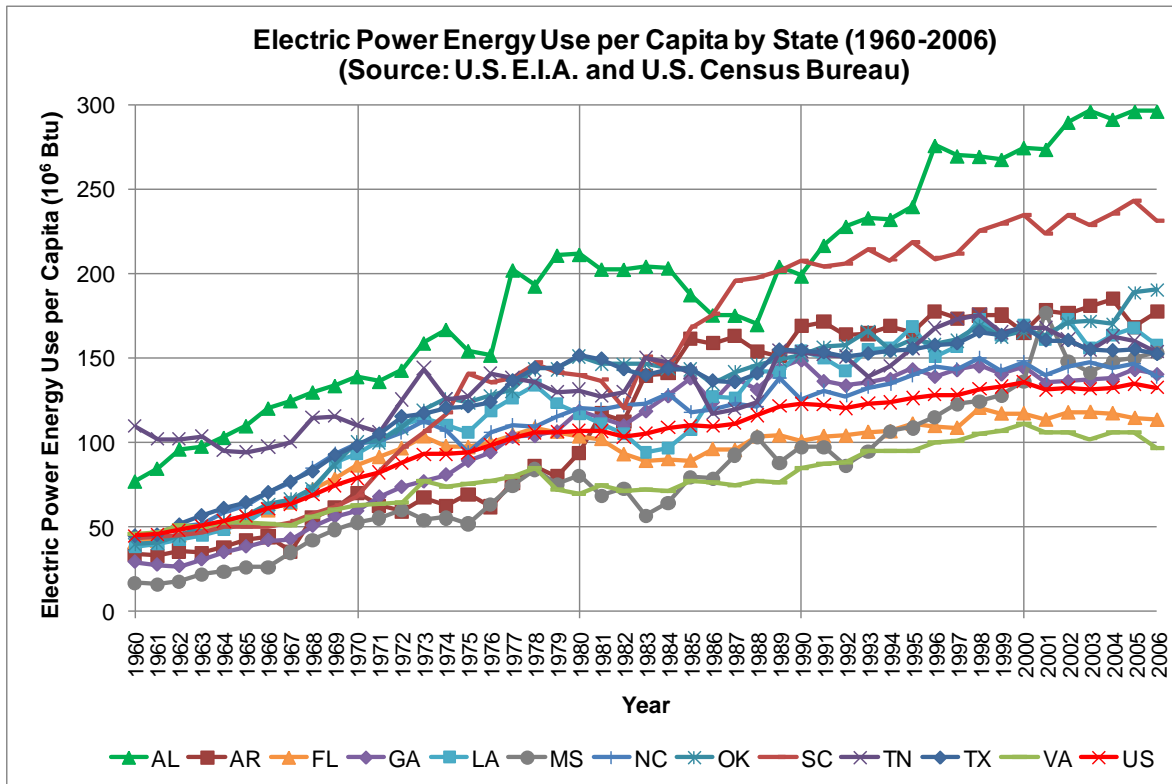


Figure 3.6.1. Energy Use per Capita by the Electric Power Sector, for the SEEC 12-States during 1960-2006.

4 ENERGY USE AND ENERGY USE PER CAPITA BY END-USE SECTOR AND FUEL SOURCE DURING 1960-2006 FOR U.S. AND EACH STATE

4.1 Overview

This section covers the historical energy use and energy use per capita by end-use sector and fuel source during 1960-2006 for the U.S. and each of the SEEC 12-states. This section can be used for a comparison of energy use within the states by end-use and by fuel-source. The end-use sectors consist of residential, commercial, industrial and transportation. The fuel sources consist of coal, natural gas, petroleum and other. Other fuel sources include nuclear electric power, hydro-electric power, biomass, geothermal, wind, photovoltaic, solar thermal energy, and net imports of electricity.

In Section 4.2, the historical U.S. total energy use, both total and per capita, is displayed by end-use sector and by fuel source. In Sections 4.3 to 4.14, each state's historical energy use, both total and per capita, is displayed by end-use sector and by fuel source. The energy consumption of electric power sector was also displayed in the chart of end-use sector energy use. For each state, the U.S. average per capita energy use is also displayed together for the purpose of a comparison. The red dotted line indicates the U.S. average energy use per capita.

Table 4.1 presents the scales that were used for the charts in Sections 4.2 to 4.14. For the purpose of a comparison and clarity, four different scales (three quadrillion Btu, five quadrillion Btu, fourteen quadrillion Btu, and 120 quadrillion Btu) were selected and used to display data in the charts of total energy use. In the charts of per capita energy use, the scale 500 million Btu, was used except for Louisiana (Section 4.7) and Texas (Section 4.13). For Louisiana and Texas, the scale 1,000 million Btu, was used. Figure 4.1.1 presents the total energy use of the SEEC-12 states during the period of 1960 to 2006 to give an idea how they are different. Per capita total energy use of the SEEC-12 states is displayed in Figure 3.2.1.

Table 4.1. Chart Scales in Sections 4.2 to 4.14.

Section Number	State	Total (Quads= 10^{15} Btu)	per Capita (10^6 Btu)
4.2	US Total	120	500
4.3	Alabama (AL)	3	500
4.4	Arkansas (AR)	3	500
4.5	Florida (FL)	5	500
4.6	Georgia (GA)	5	500
4.7	Louisiana (LA)	5	1,000
4.8	Mississippi (MS)	3	500
4.9	North Carolina (NC)	3	500
4.10	Oklahoma (OK)	3	500
4.11	South Carolina (SC)	3	500
4.12	Tennessee (TN)	3	500
4.13	Texas (TX)	14	1,000
4.14	Virginia (VA)	3	500

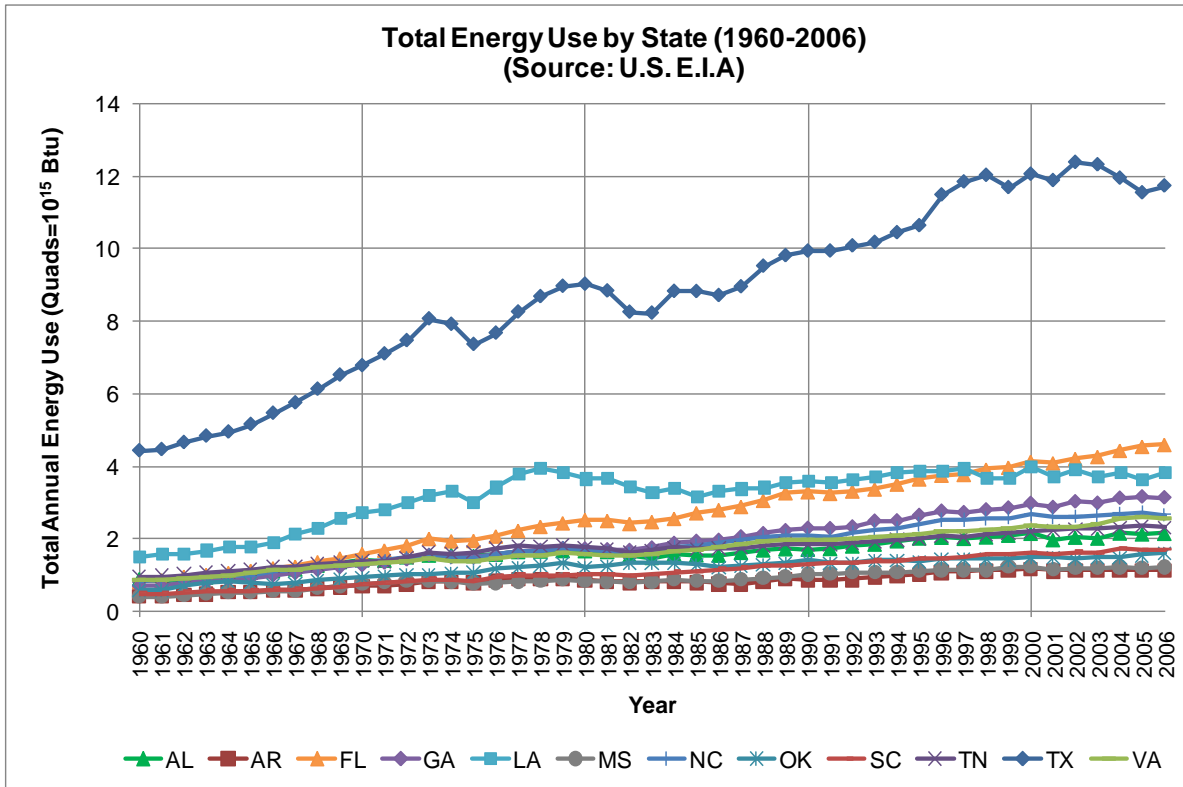


Figure 4.1.1. Total Energy Use, for the SEEC 12-States during 1960-2006.

4.2 U.S. Total

Figure 4.2.1 and Figure 4.2.2, respectively, show the total and per capita energy use of the U.S. by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.2.3 and Figure 4.2.4, respectively, show the total and per capita energy use of the U.S. by fuel source during the period of 1960 to 2006. The U.S. total energy use has been continuously rising while per capita U.S. energy use has remained constant. Since 2000, the electric power sector consumed the largest amount of total energy among end-use sectors, followed by industrial, transportation, residential and commercial. By fuel source, the energy consumption of petroleum-based products distinctly occupied the largest proportion of the total. There were little differences between natural gas and coal products, and other fuel sources occupied the smallest proportion.

The total population and energy use information for the U.S. in 2006 is as follows:

- U.S. Total Population (2006): 298,362,973
- U.S. Total Energy Use (Quads= 10^{15} Btu, 2006): 99.52 Quads

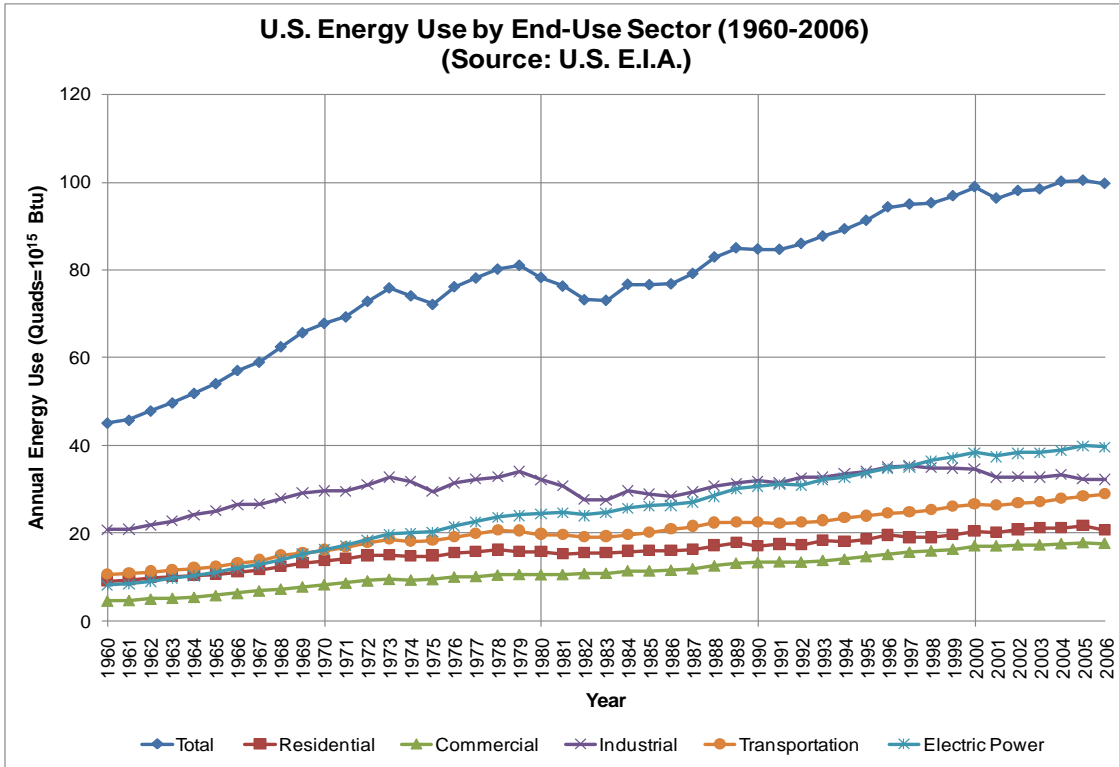


Figure 4.2.1. U.S. Total Energy Use by End-Use Sector during 1960-2006.

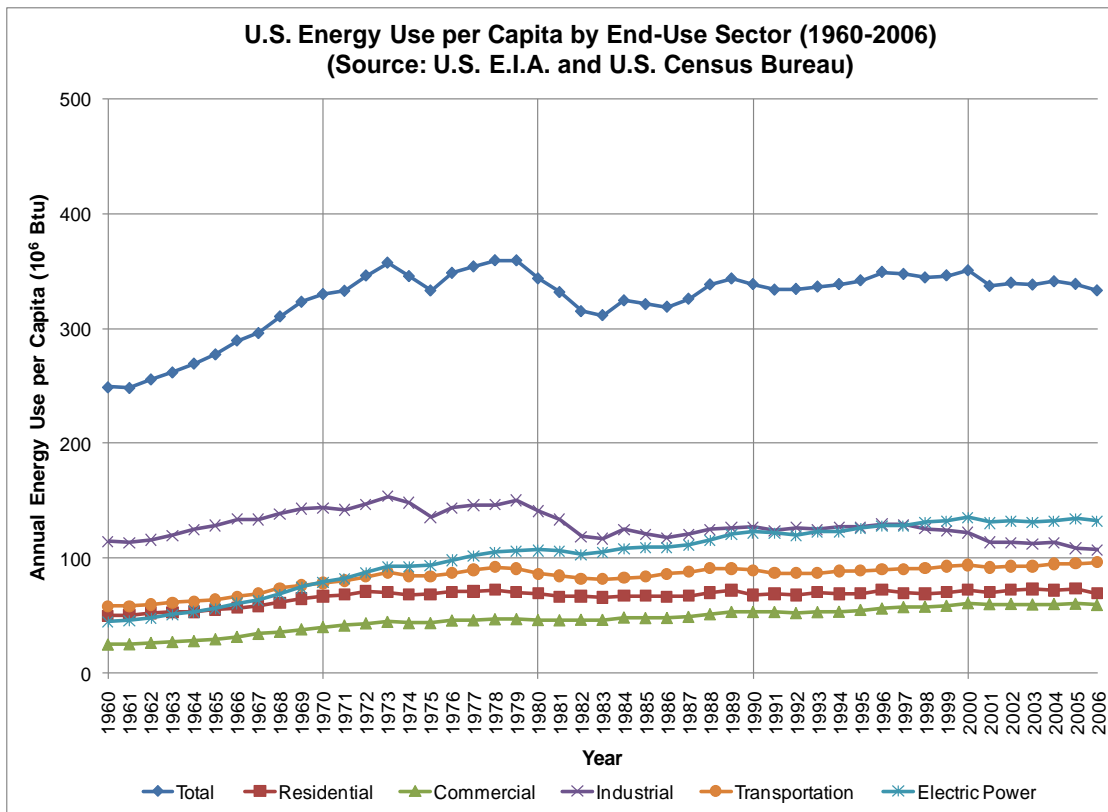


Figure 4.2.2. U.S. Total Energy Use per Capita by End-Use Sector during 1960-2006.

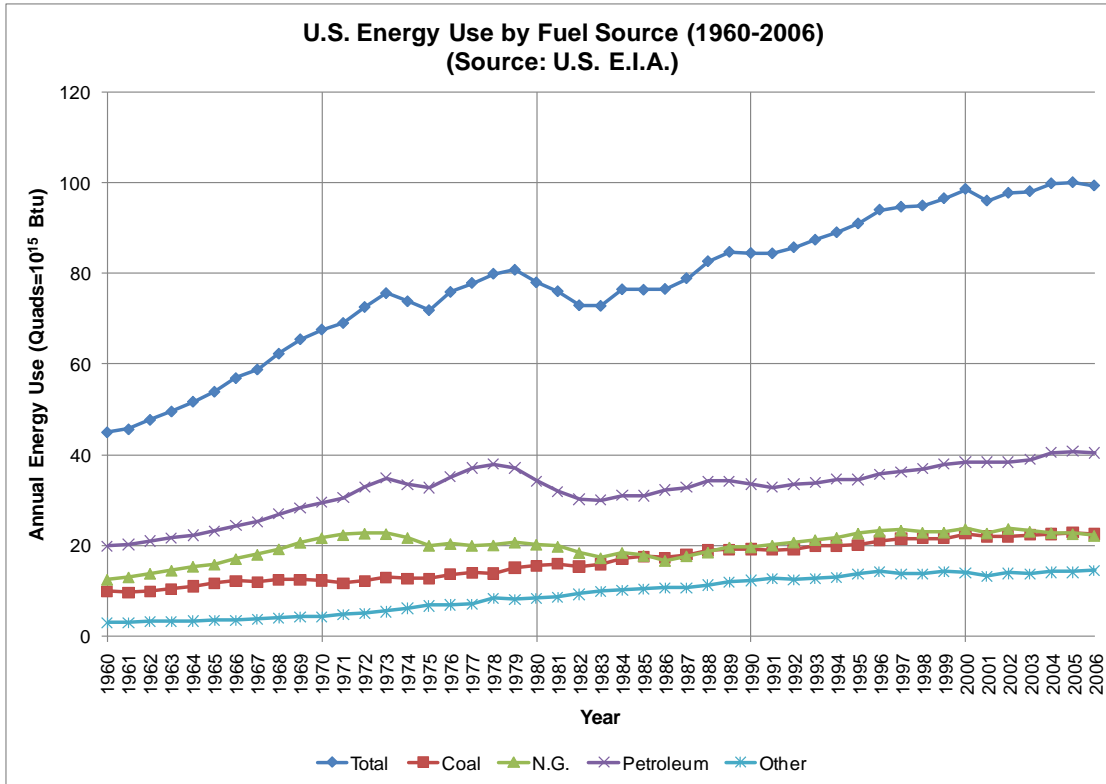


Figure 4.2.3. U.S. Total Energy Use by Fuel Source during 1960-2006.

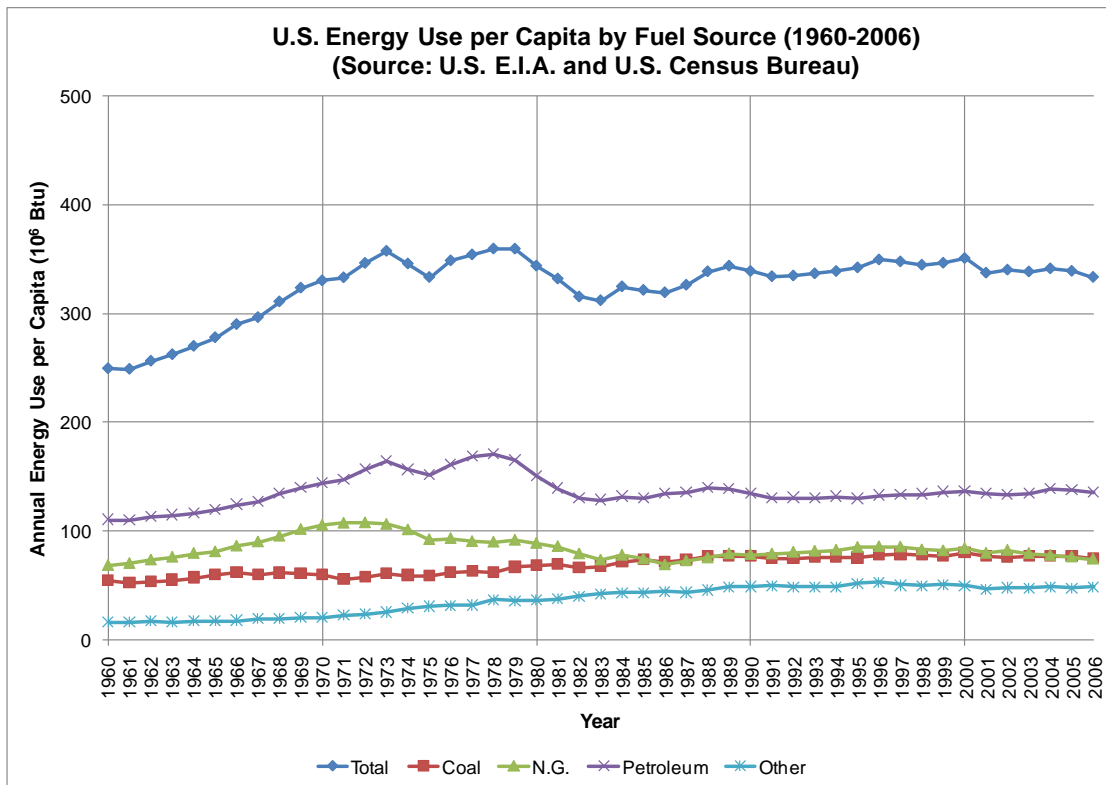


Figure 4.2.4. U.S. Total Energy Use per Capita by Fuel Source during 1960-2006.

4.3 Alabama

Figure 4.3.1 and Figure 4.3.2, respectively, show the total and per capita energy use of Alabama by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.3.3 and Figure 4.3.4, respectively, show the total and per capita energy use of Alabama by fuel source during the period of 1960 to 2006. Alabama's energy use, both total and per capita, has been continuously rising even though the increased rate of per capita energy use is much smaller than that of the total. Since 2000, the energy uses of all end-use sectors and all fuel sources have remained relatively flat except the electric power sector. The electric power sector consumed the largest amount of total energy among end-use sectors, followed by industrial, transportation, residential and commercial. By fuel source, the energy consumption of coal-based products distinctly occupied the largest proportion of the total. There were little differences between petroleum and other fuel source products, and natural gas occupied the smallest proportion. It is noticeable that the energy consumption of other fuel source products has suddenly increased since the middle of the 1970's.

The total population and energy use information for Alabama in 2006 is as follows:

- Alabama Total Population (2006): 4,587,564
- Alabama Total Energy Use (Quads= 10^{15} Btu, 2006): 2.14 Quads

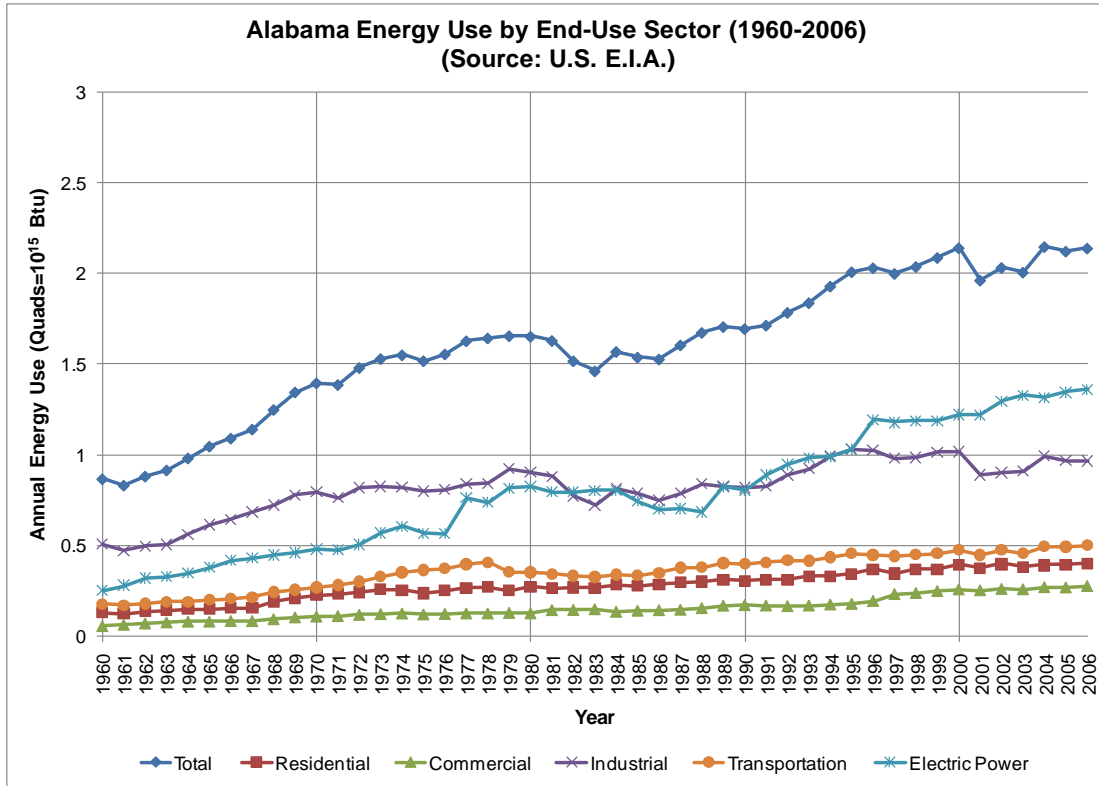


Figure 4.3.1. Alabama Energy Use by End-Use Sector during 1960-2006.

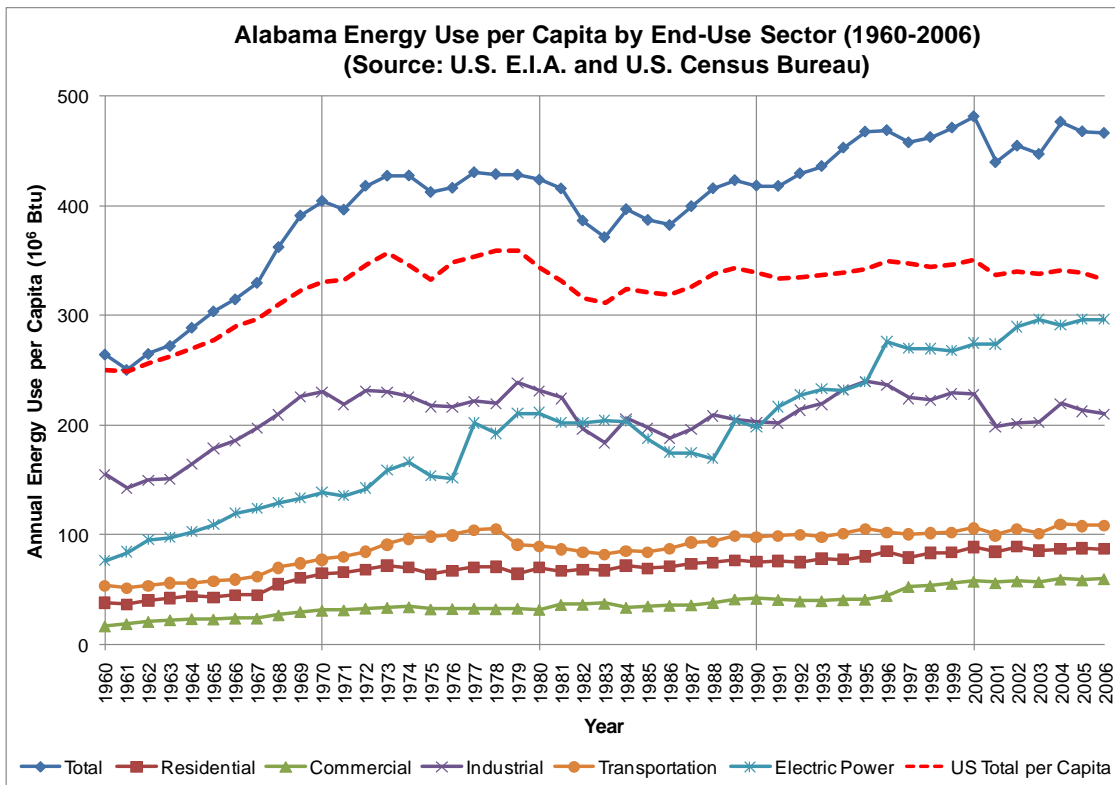


Figure 4.3.2. Alabama Energy Use per Capita by End-Use Sector during 1960-2006.

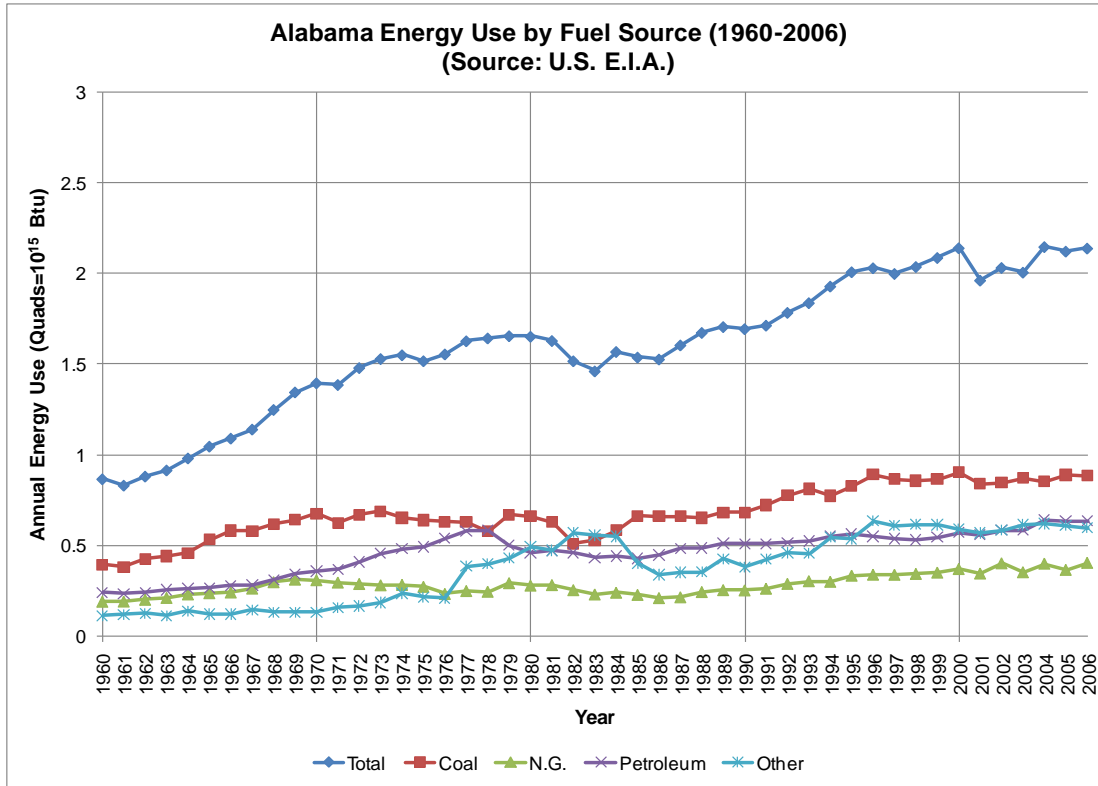


Figure 4.3.3. Alabama Energy Use by Fuel Source during 1960-2006.

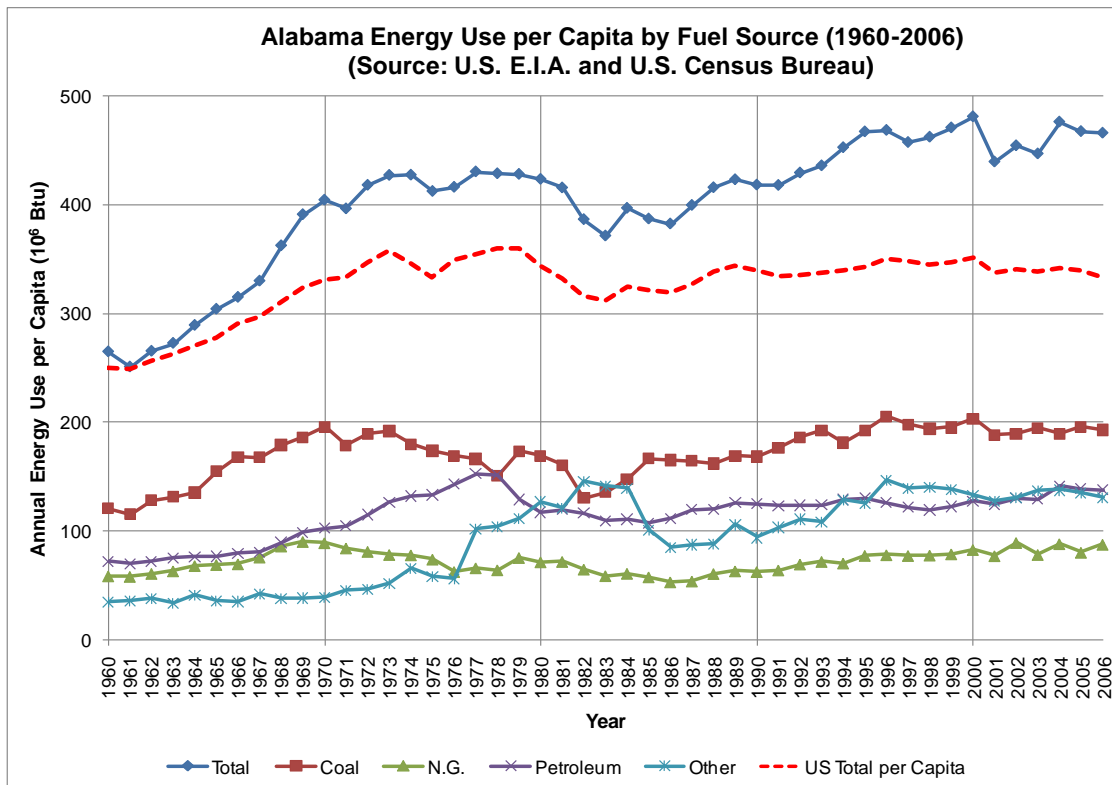


Figure 4.3.4. Alabama Energy Use per Capita by Fuel Source during 1960-2006.

4.4 Arkansas

Figure 4.4.1 and Figure 4.4.2, respectively, show the total and per capita energy use of Arkansas by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.4.3 and Figure 4.4.4, respectively, show the total and per capita energy use of Arkansas by fuel source during the period of 1960 to 2006. Arkansas's energy use, both total and per capita, has been slightly rising even though there was a slight decline between the late 1970's and the middle 1980's. Since the middle 1990's, the energy use has remained constant, but Arkansas' energy use per capita is still beyond the U.S. average per capita. Both the electric power and the industrial sectors were the largest consuming sectors among end-use sectors, followed by transportation, residential and commercial. By fuel source, the energy consumption of petroleum-based products occupied the largest proportion of the total, and there were little differences among others. It is noticeable that the energy consumption of both coal and other fuel source products has started increasing in the late 1970's, while energy consumption of natural gas and petroleum products has decreased in the same period.

The total population and energy use information for Arkansas in 2006 is as follows:

- Arkansas Total Population (2006): 2,804,199
- Arkansas Total Energy Use (Quads= 10^{15} Btu, 2006): 1.14 Quads

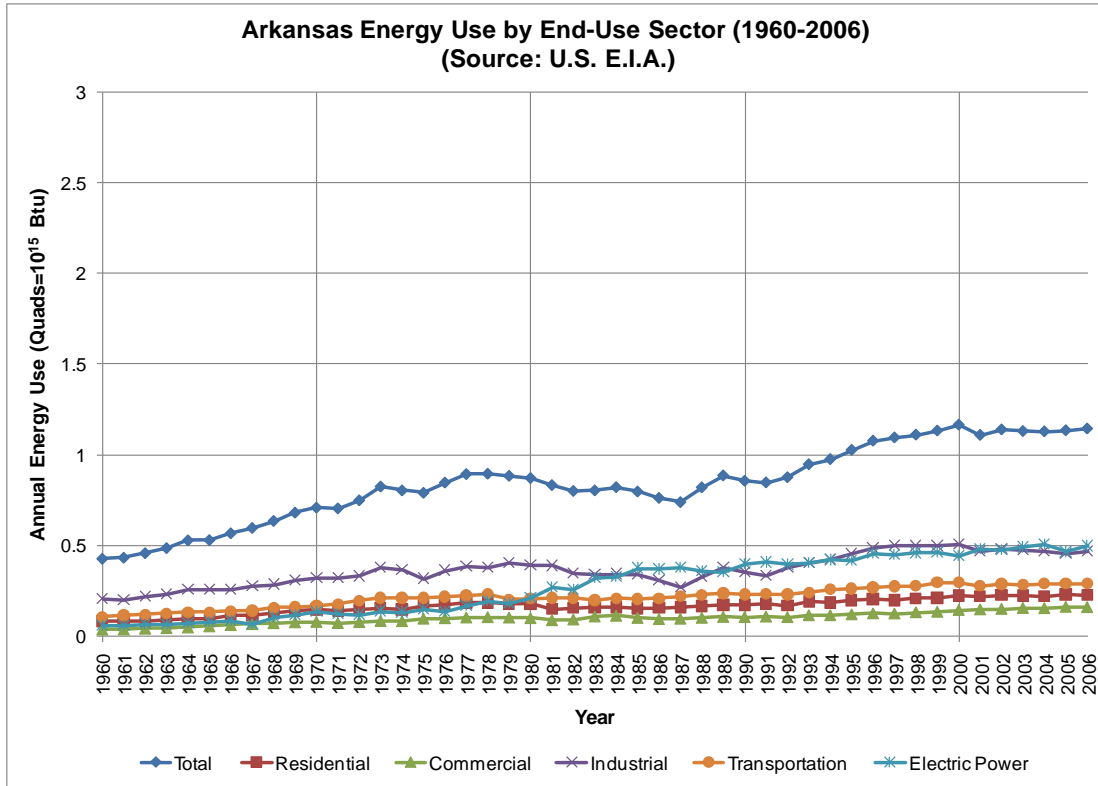


Figure 4.4.1. Arkansas Energy Use by End-Use Sector during 1960-2006.

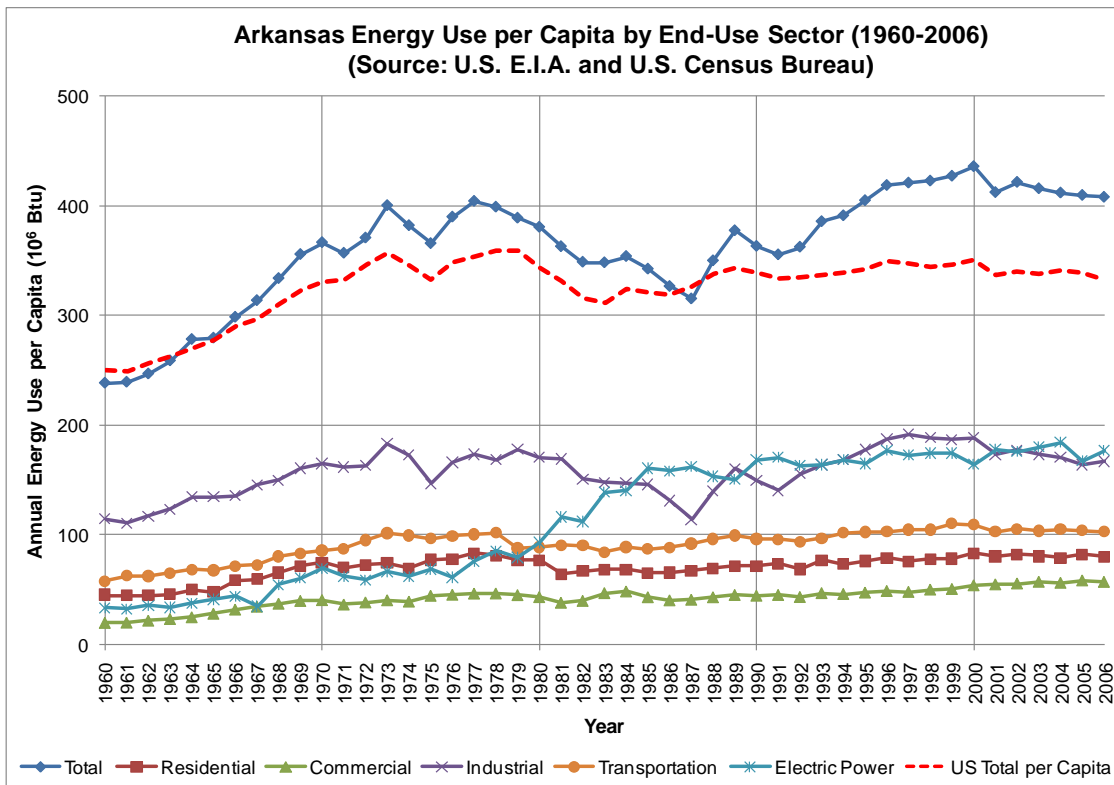


Figure 4.4.2. Arkansas Energy Use per Capita by End-Use Sector during 1960-2006.

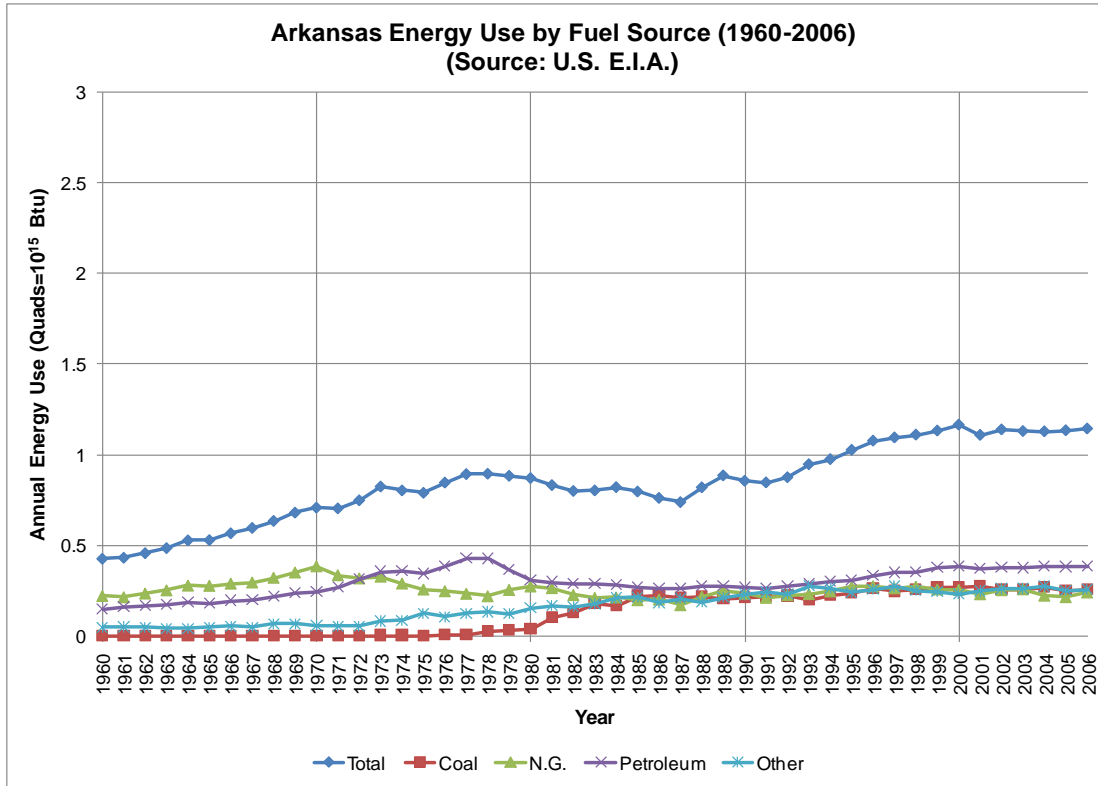


Figure 4.4.3. Arkansas Energy Use by Fuel Source during 1960-2006.

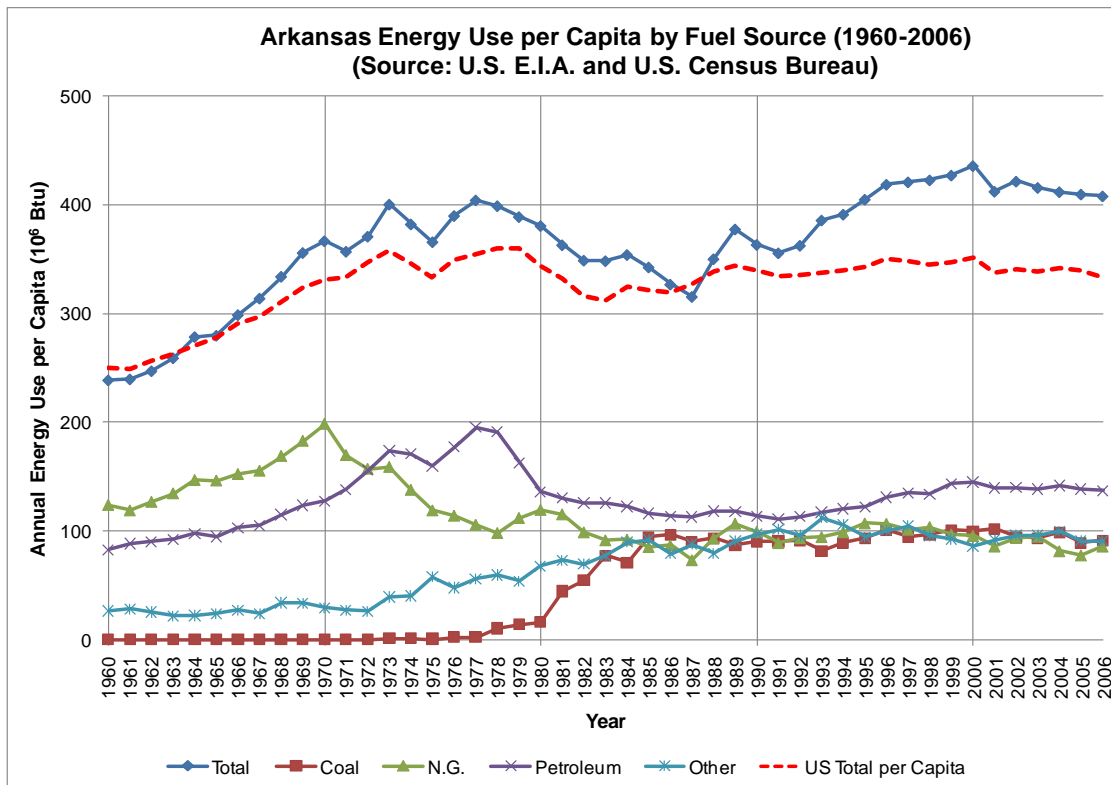


Figure 4.4.4. Arkansas Energy Use per Capita by Fuel Source during 1960-2006.

4.5 Florida

Figure 4.5.1 and Figure 4.5.2, respectively, show the total and per capita energy use of Florida by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.5.3 and Figure 4.5.4, respectively, show the total and per capita energy use of Florida by fuel source during the period of 1960 to 2006. Florida's total energy use has been continuously rising while per capita energy use has remained constant. The increased rate of Florida's total use is also very high, but Florida's energy use per capita is less than the U.S. average per capita. The electric power sector consumed the largest amount of total energy among end-use sectors, followed by transportation, residential, commercial and industrial. It is noticeable that the industrial sector is the smallest consuming sector and has decreased since 2000. By fuel source, the energy consumption of petroleum-based products distinctly occupied the largest proportion of the total, and there were little differences among others.

The total population and energy use information for Florida in 2006 is as follows:

- Florida Total Population (2006): 18,019,093
- Florida Total Energy Use (Quads= 10^{15} Btu, 2006): 4.61 Quads

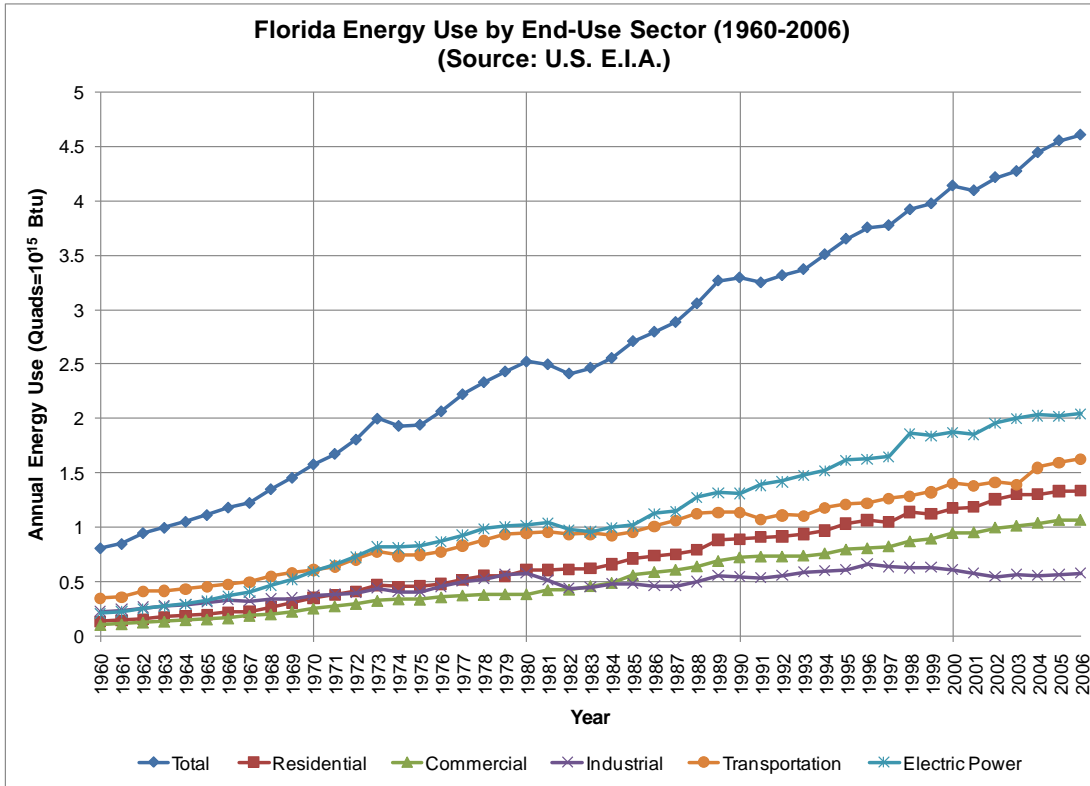


Figure 4.5.1. Florida Energy Use by End-Use Sector during 1960-2006.

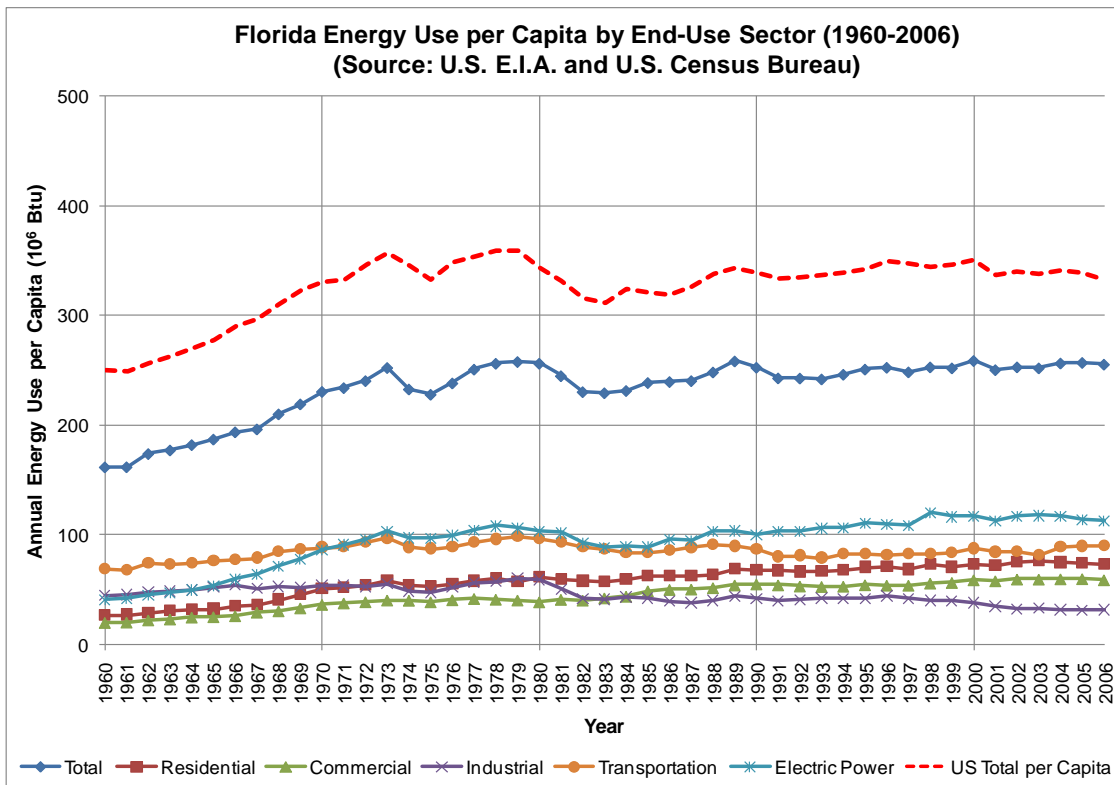


Figure 4.5.2. Florida Energy Use per Capita by End-Use Sector during 1960-2006.

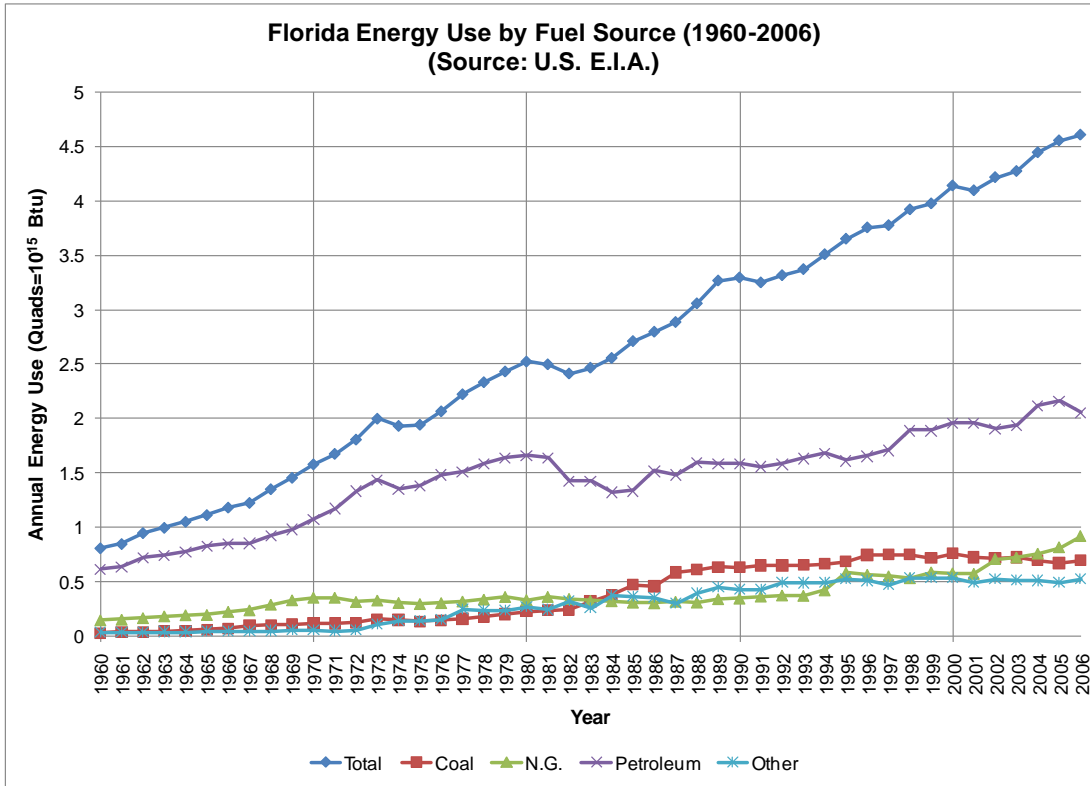


Figure 4.5.3. Florida Energy Use by Fuel Source during 1960-2006.

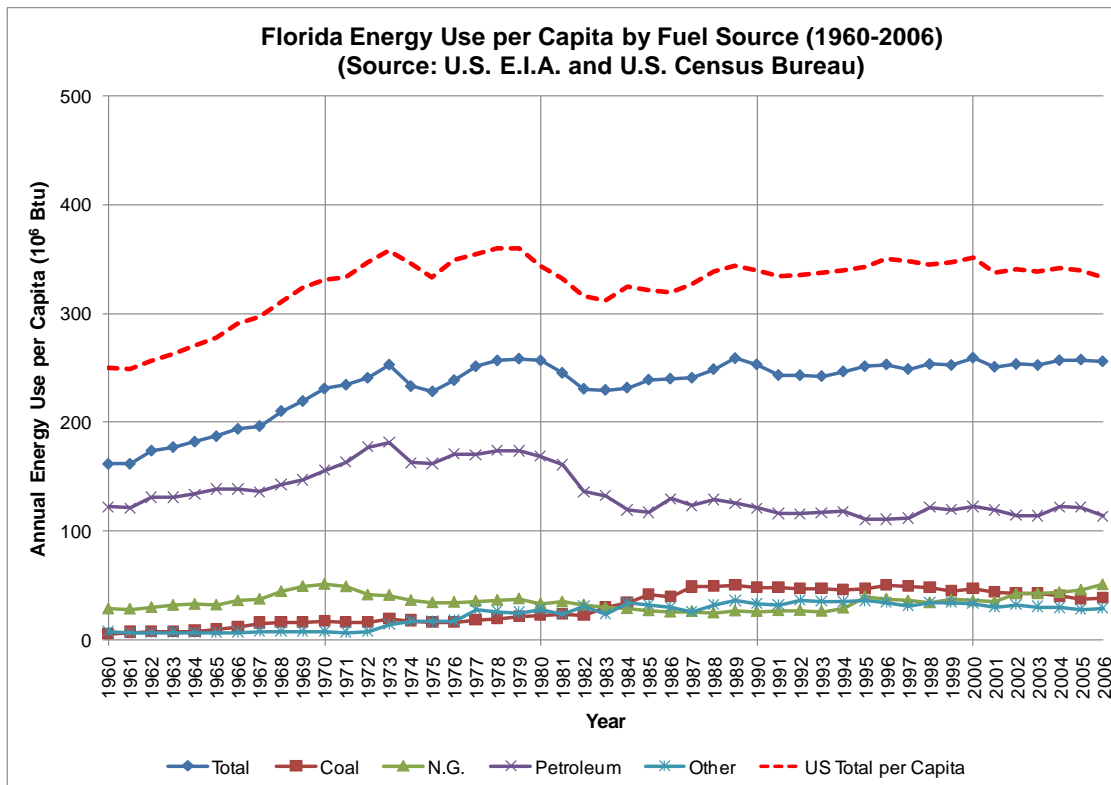


Figure 4.5.4. Florida Energy Use per Capita by Fuel Source during 1960-2006.

4.6 Georgia

Figure 4.6.1 and Figure 4.6.2, respectively, show the total and per capita energy use of Georgia by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.6.3 and Figure 4.6.4, respectively, show the total and per capita energy use of Georgia by fuel source during the period of 1960 to 2006. Georgia's energy use has been continuously rising while per capita energy use has remained constant. Georgia's energy use per capita is very similar to the U.S. average per capita. The electric power sector consumed the largest amount of total energy among end-use sectors, and both the industrial and the transportation were the second largest consuming sectors, followed by residential and commercial. By fuel source, the energy consumption of petroleum-based products occupied the largest proportion of the total, followed by coal, other fuel source, and natural gas. It is noticeable that the energy consumption of other fuel source products has suddenly increased since the late 1980's.

The total population and energy use information for Georgia in 2006 is as follows:

- Georgia Total Population (2006): 9,318,715
- Georgia Total Energy Use (Quads= 10^{15} Btu, 2006): 3.15 Quads

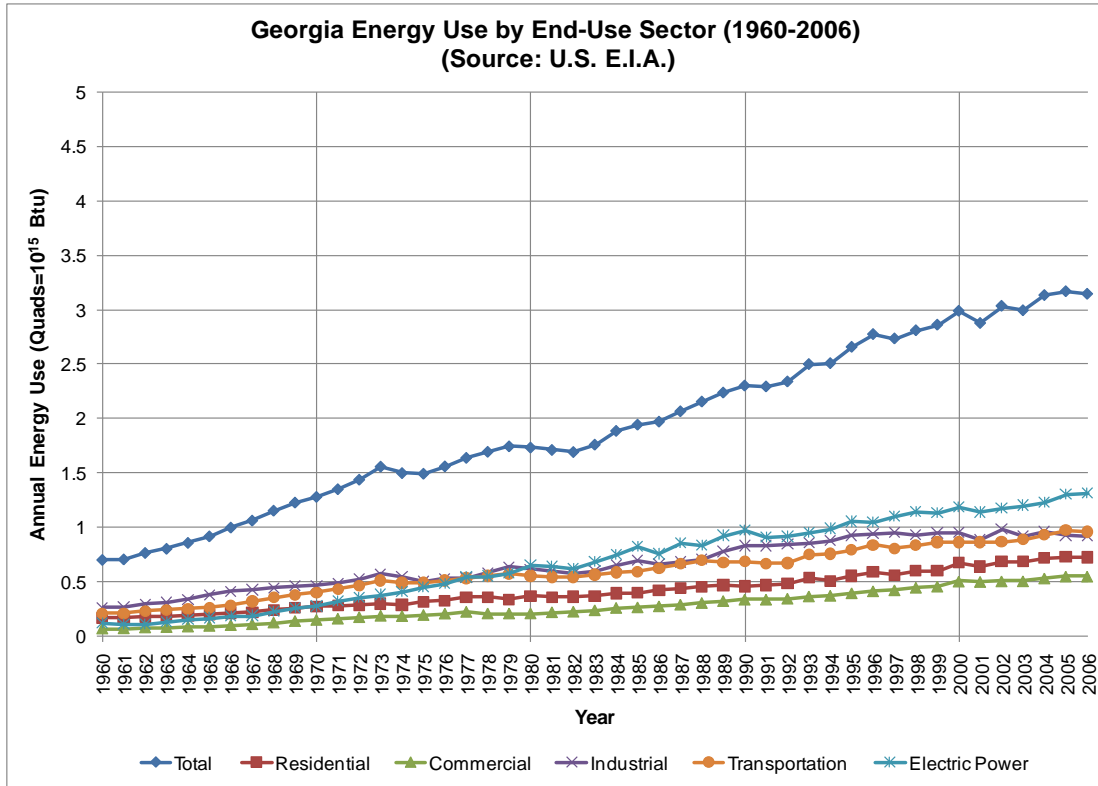


Figure 4.6.1. Georgia Energy Use by End-Use Sector during 1960-2006.

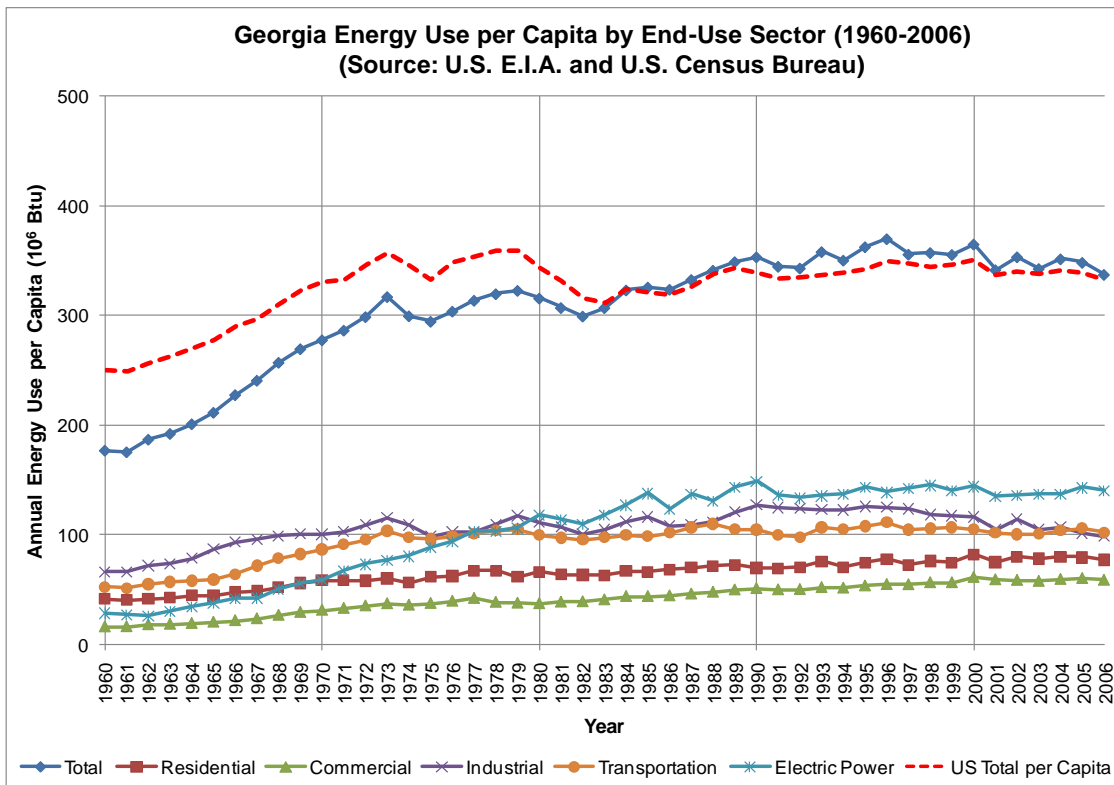


Figure 4.6.2. Georgia Energy Use per Capita by End-Use Sector during 1960-2006.

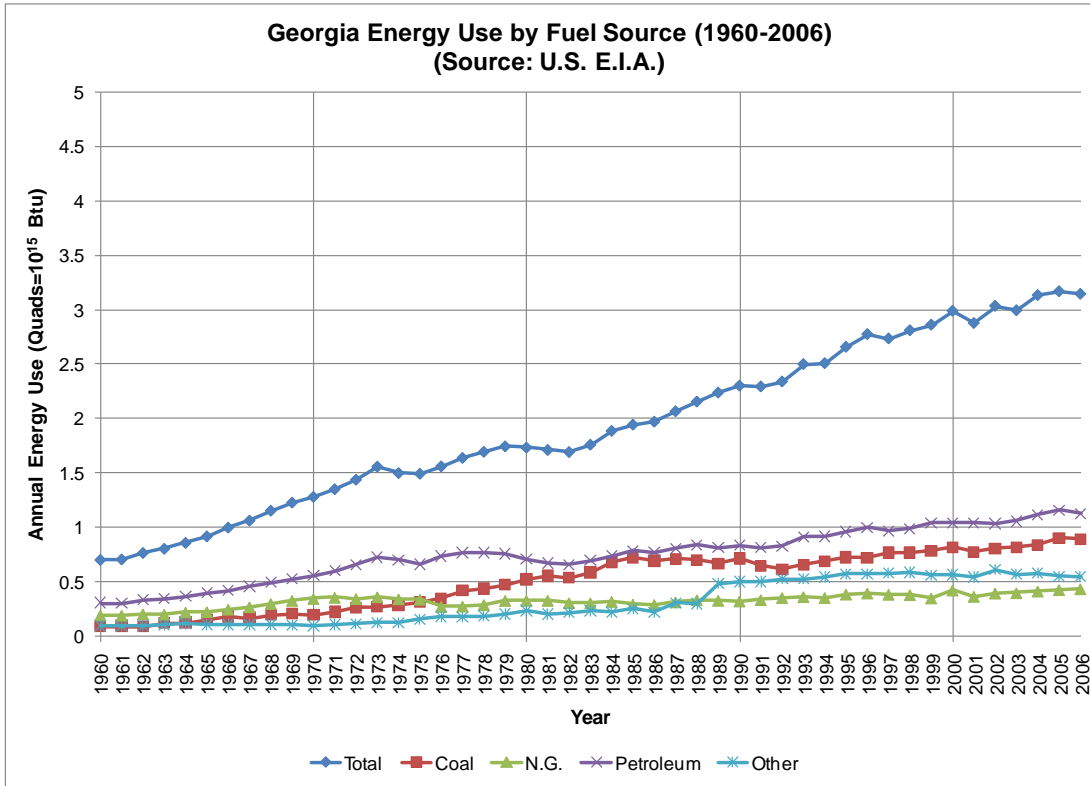


Figure 4.6.3. Georgia Energy Use by Fuel Source during 1960-2006.

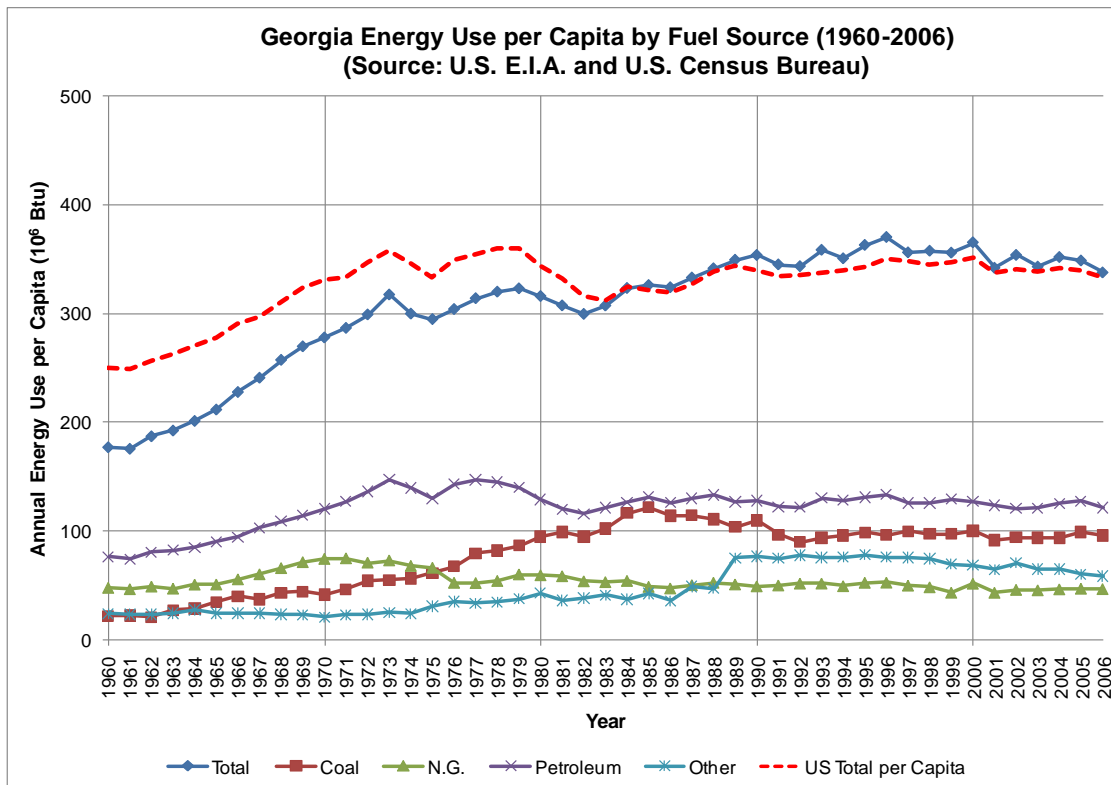


Figure 4.6.4. Georgia Energy Use per Capita by Fuel Source during 1960-2006.

4.7 Louisiana

Figure 4.7.1 and Figure 4.7.2, respectively, show the total and per capita energy use of Louisiana by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.7.3 and Figure 4.7.4, respectively, show the total and per capita energy use of Louisiana by fuel source during the period of 1960 to 2006. Louisiana's energy use, both total and per capita, had been rapidly rising until the late 1970's, however, there was a decline between the late 1970's and the middle 1980's. It then started to increase again, and since the middle 1990's, the energy use has remained constant, keeping fluctuations within a narrow range. Louisiana's energy use per capita is far beyond the U.S. average per capita. The industrial sector consumed the largest amount of total energy among end-use sectors, and both the transportation and the electric power were the second largest consuming sectors, followed by residential and commercial. It is noticeable that the industrial sector is solely higher than the U.S. average per capita. By fuel source, the energy consumption of petroleum-based products occupied the largest proportion of the total, followed by natural gas, other fuel source, and coal. The energy consumption of natural-gas-based products had been high; since 2000, energy use of petroleum-based products has started higher than that of natural-gas-based products. There were little differences between other fuel source and coal products.

The total population and energy use information for Alabama in 2006 is as follows:

- Louisiana Total Population (2006): 4,243,634
- Louisiana Total Energy Use (Quads= 10^{15} Btu, 2006): 3.80 Quads

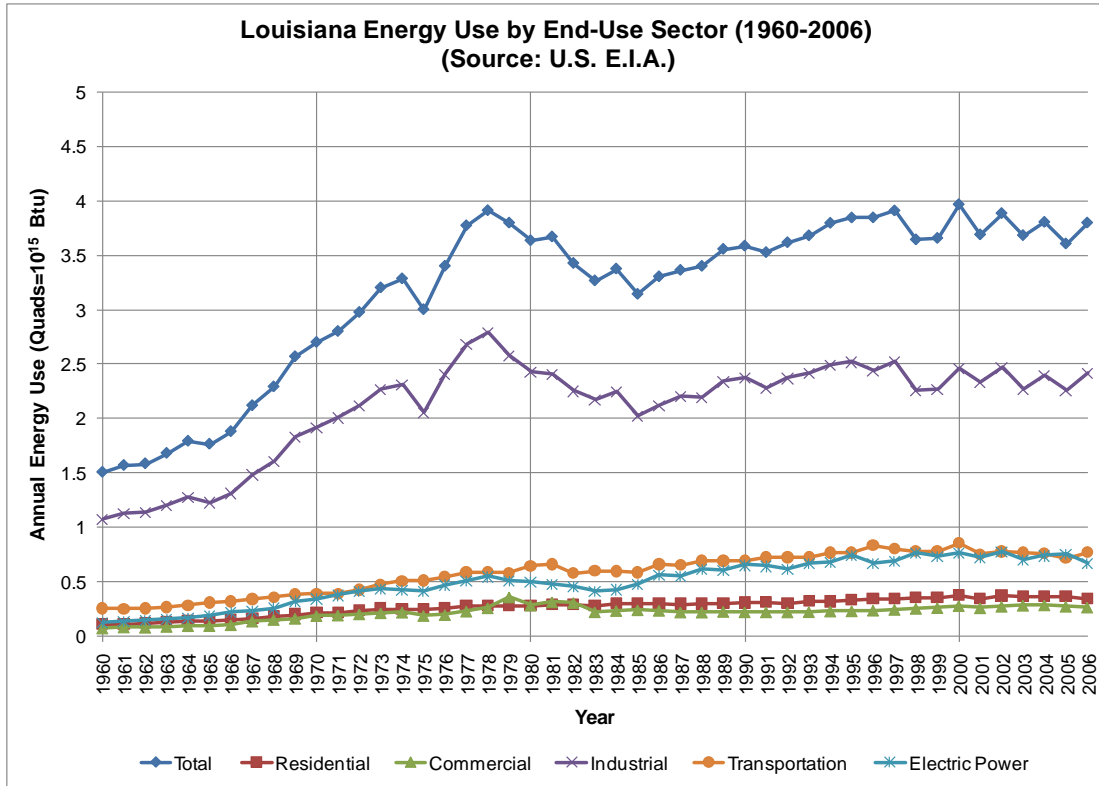


Figure 4.7.1. Louisiana Energy Use by End-Use Sector during 1960-2006.

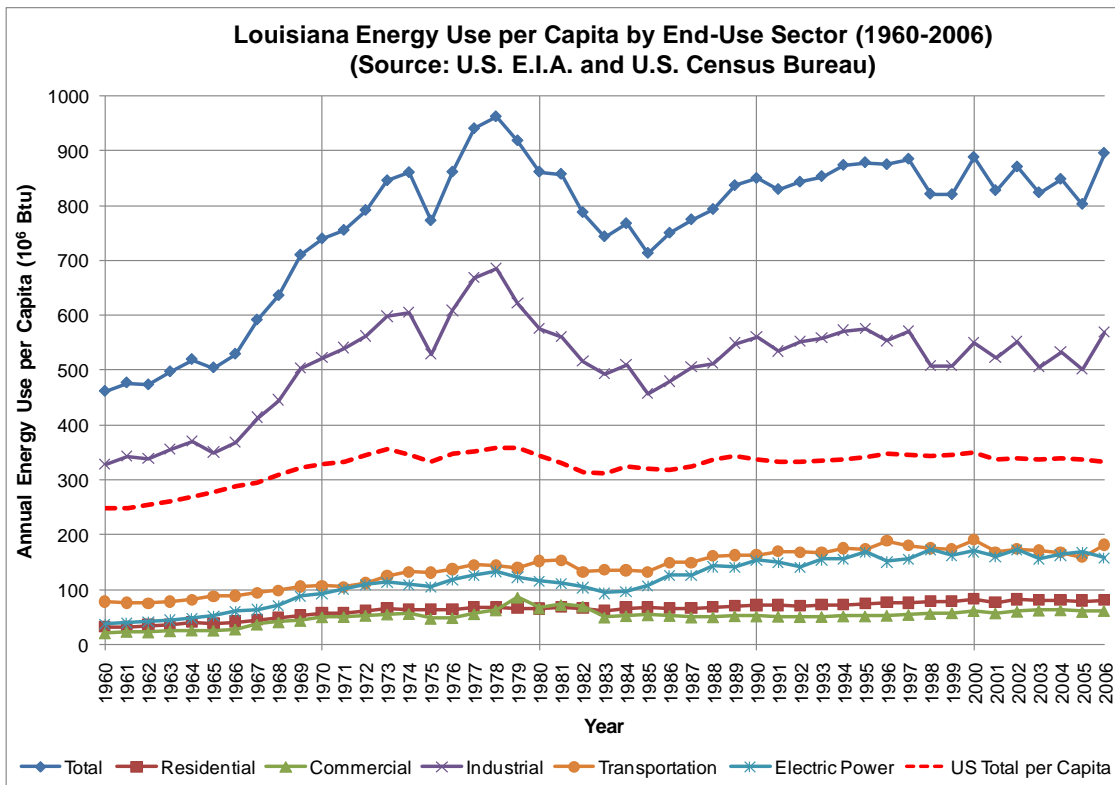


Figure 4.7.2. Louisiana Energy Use per Capita by End-Use Sector during 1960-2006.

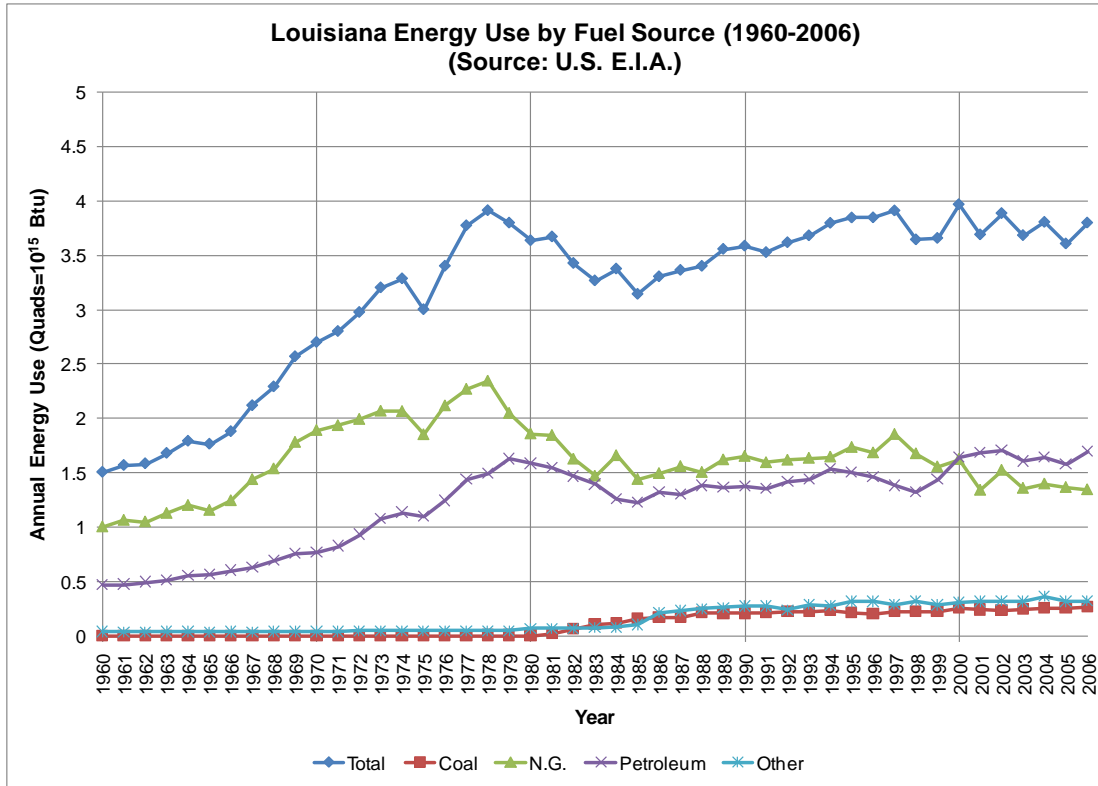


Figure 4.7.3. Louisiana Energy Use by Fuel Source during 1960-2006.

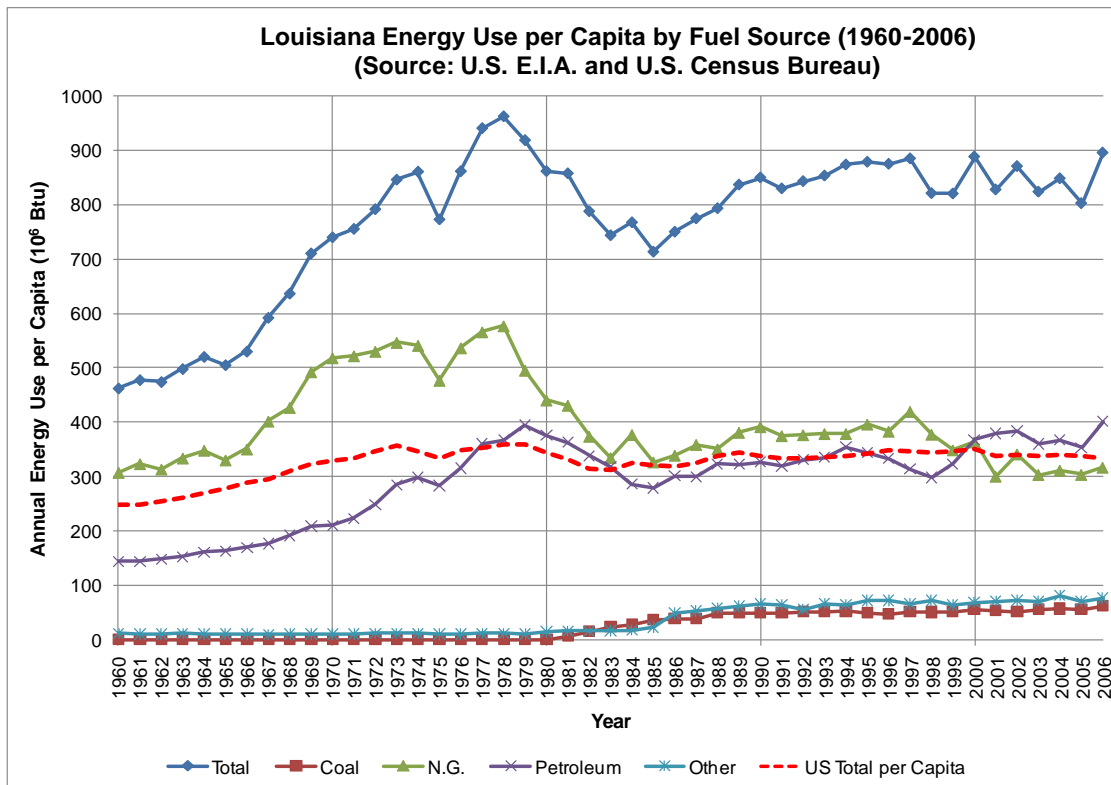


Figure 4.7.4. Louisiana Energy Use per Capita by Fuel Source during 1960-2006.

4.8 Mississippi

Figure 4.8.1 and Figure 4.8.2, respectively, show the total and per capita energy use of Mississippi by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.8.3 and Figure 4.8.4, respectively, show the total and per capita energy use of Mississippi by fuel source during the period of 1960 to 2006. Mississippi's energy use, both total and per capita, had been slightly rising, although since 1990 it has remained constant, keeping little fluctuations. Mississippi's energy use per capita has started beyond the U.S. average per capita since the middle 1980's. Both the electric power and the industrial sectors were the largest consuming sectors among end-use sectors, followed by transportation, residential and commercial. By fuel source, the energy consumption of petroleum based products distinctly occupied the largest proportion of the total, followed by natural gas, coal, and other fuel sources. There were little differences between coal and other fuel source products.

The total population and energy use information for Mississippi in 2006 is as follows:

- Mississippi Total Population (2006): 2,896,713
- Mississippi Total Energy Use (Quads= 10^{15} Btu, 2006): 1.22 Quads

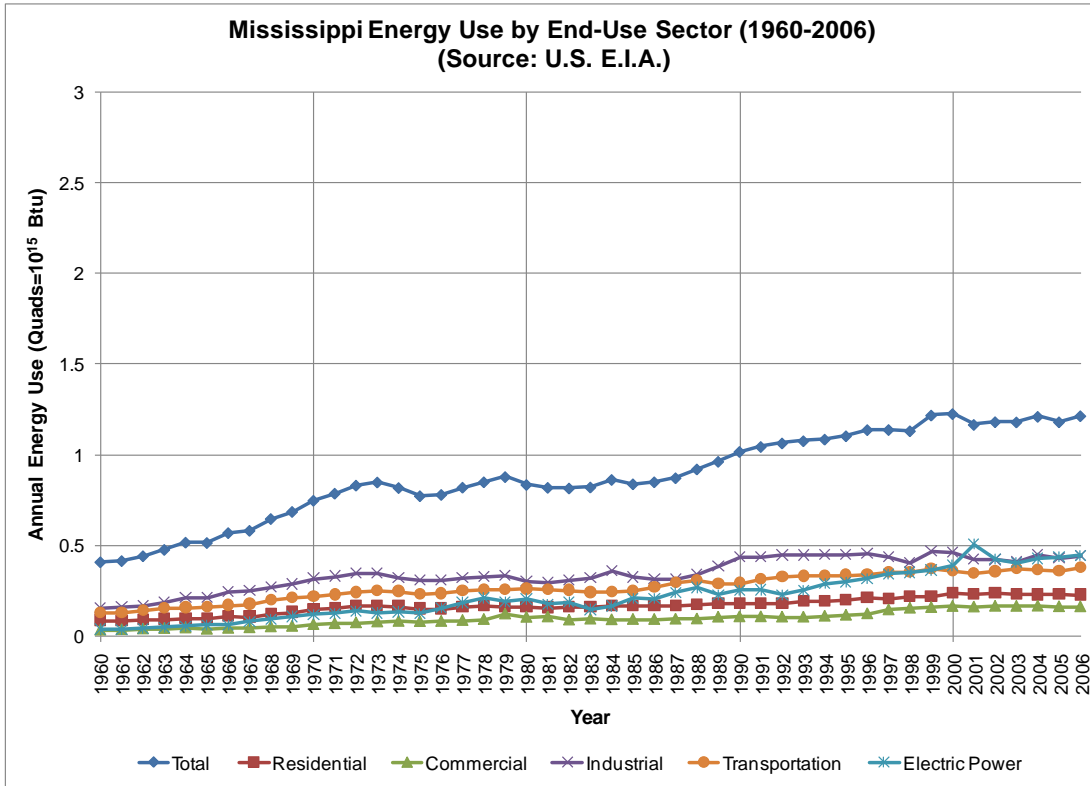


Figure 4.8.1. Mississippi Energy Use by End-Use Sector during 1960-2006.

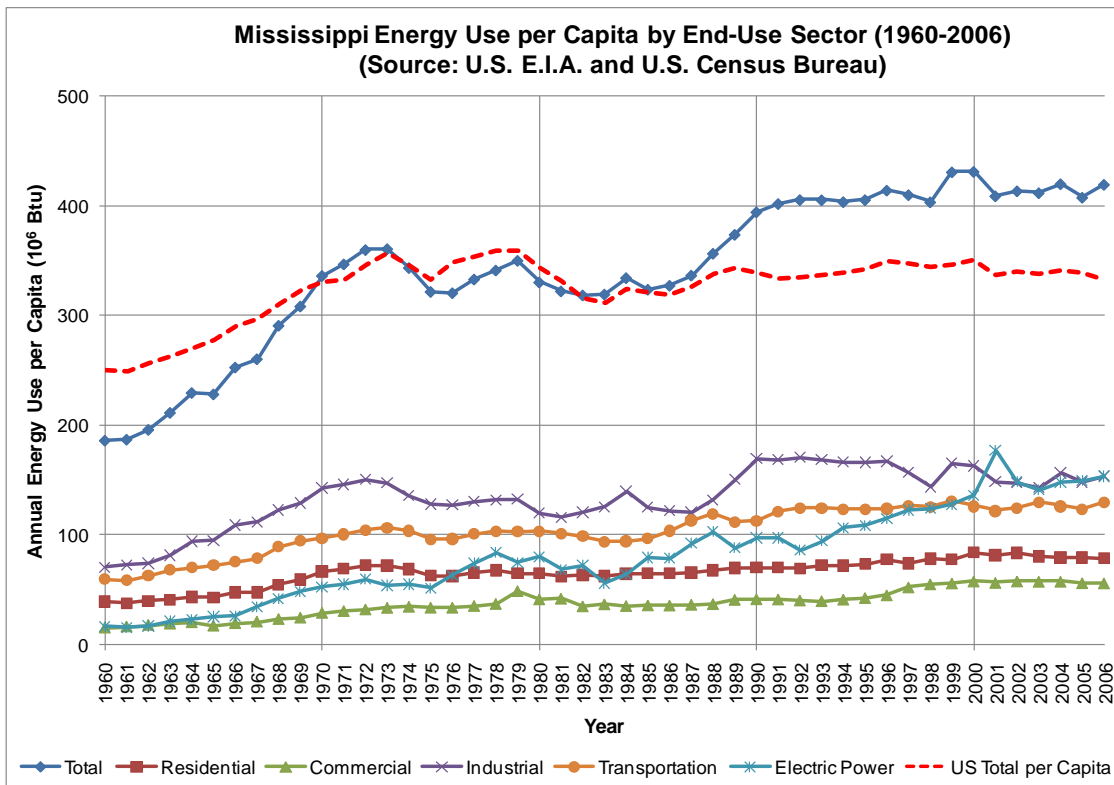


Figure 4.8.2. Mississippi Energy Use per Capita by End-Use Sector during 1960-2006.

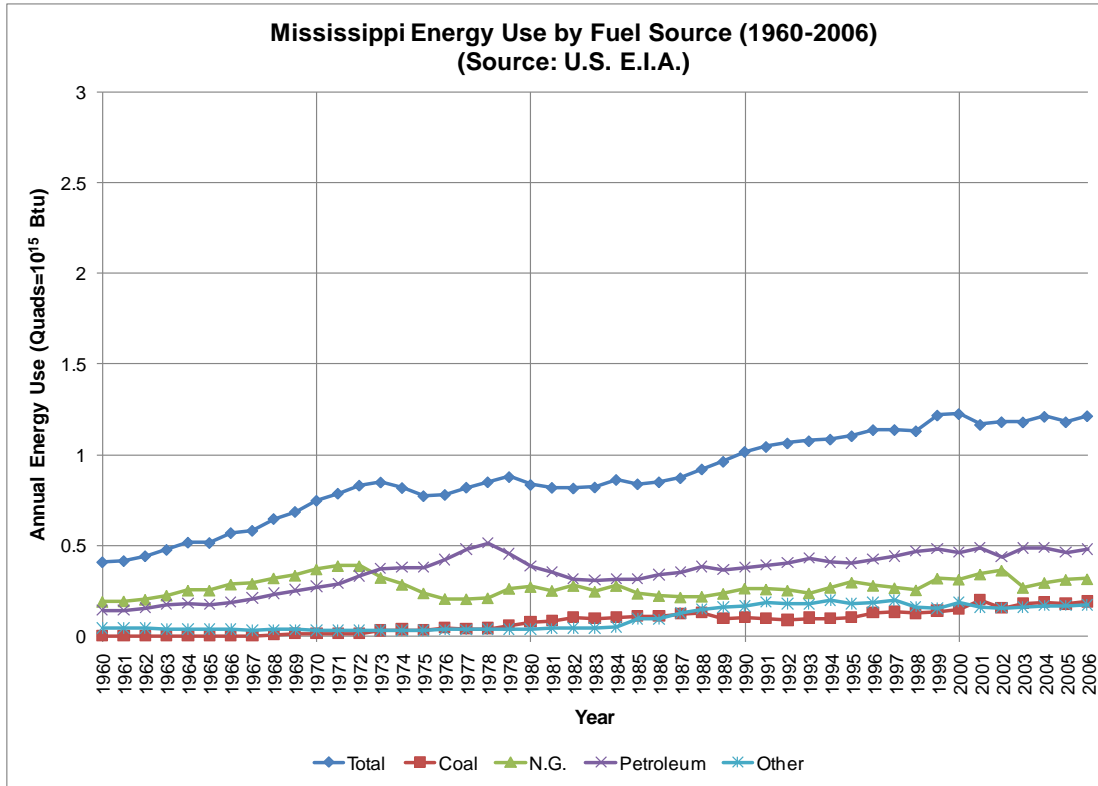


Figure 4.8.3. Mississippi Energy Use by Fuel Source during 1960-2006.

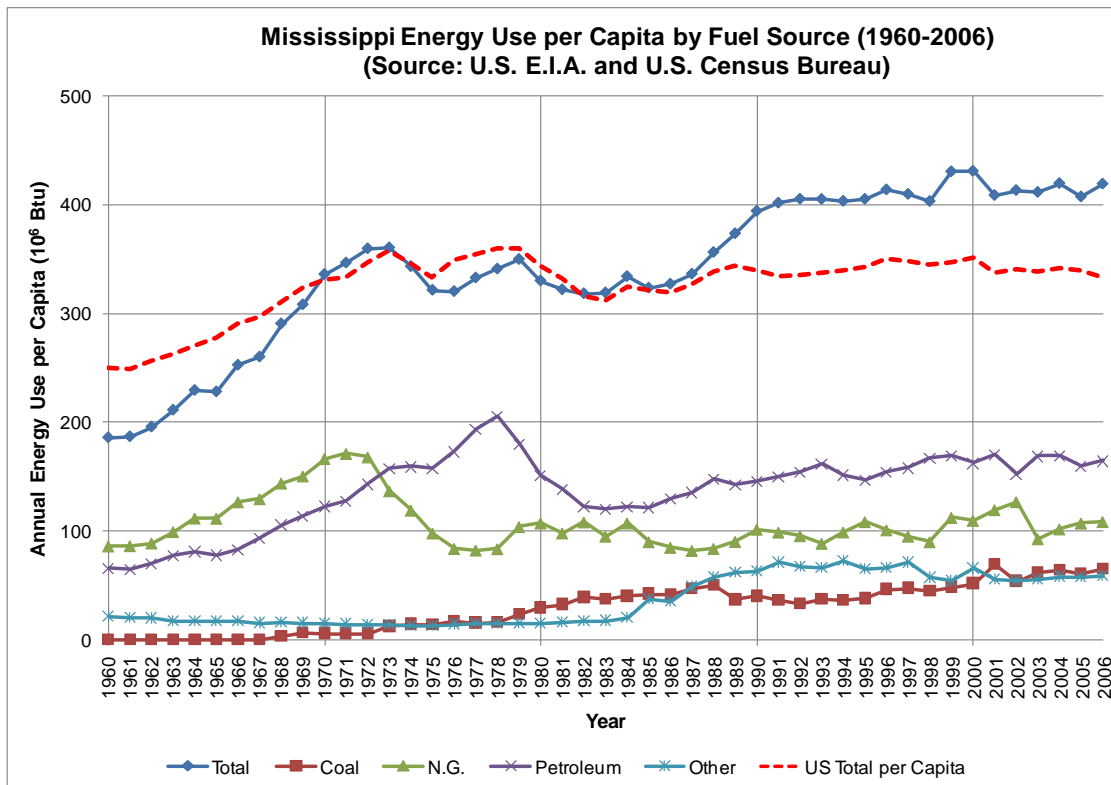


Figure 4.8.4. Mississippi Energy Use per Capita by Fuel Source during 1960-2006.

4.9 North Carolina

Figure 4.9.1 and Figure 4.9.2, respectively, show the total and per capita energy use of North Carolina by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.9.2 and Figure 4.9.3, respectively, show the total and per capita energy use of North Carolina by fuel source during the period of 1960 to 2006. North Carolina's total energy use has been continuously rising while per capita energy use has remained constant. North Carolina's energy use per capita is less than the U.S. average per capita. The electric power sector consumed the largest amount of total energy among end-use sectors. Among other three sectors, including industrial, transportation, and residential, there were little differences, and the commercial sector consumed the smallest proportion. By fuel source, the energy consumption of petroleum-based products occupied the largest proportion of the total, followed by coal, other fuel sources, and natural gas. It is noticeable that the energy consumption of other fuel source products had increased in the early 1980's.

The total population and energy use information for North Carolina in 2006 is as follows:

- North Carolina Total Population (2006): 8,845,343
- North Carolina Total Energy Use (Quads= 10^{15} Btu, 2006): 2.66 Quads

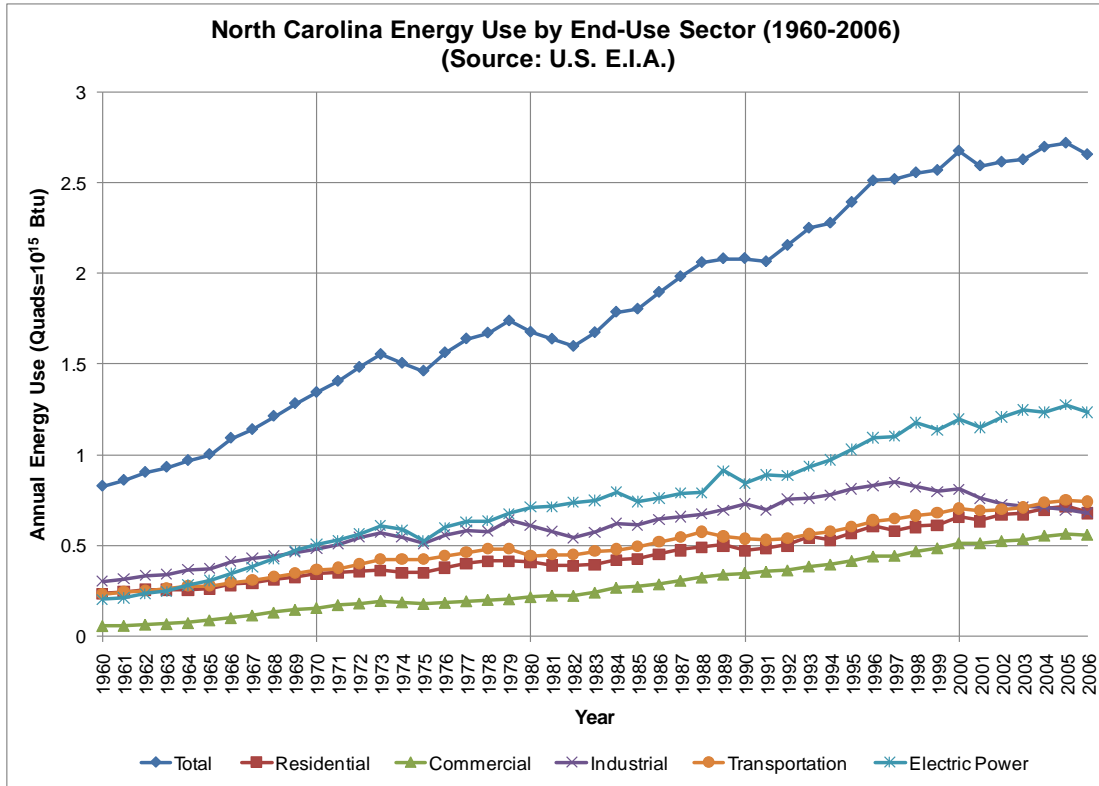


Figure 4.9.1. North Carolina Energy Use by End-Use Sector during 1960-2006.

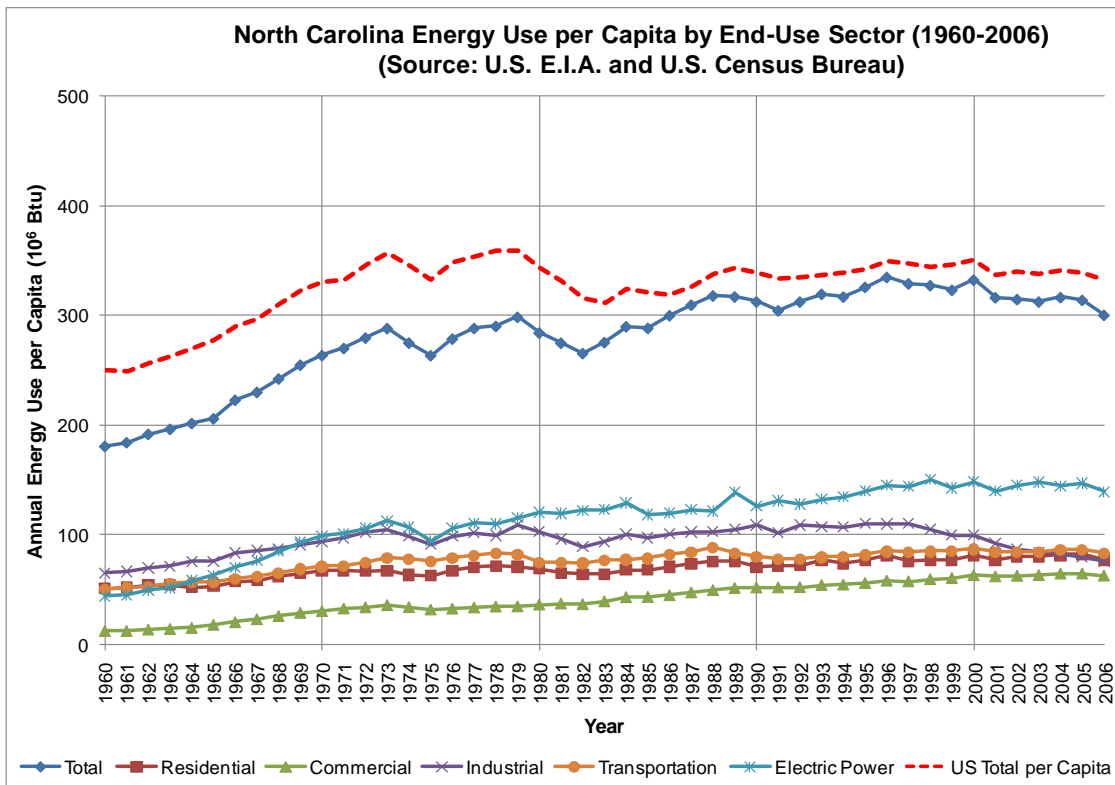


Figure 4.9.2. North Carolina Energy Use per Capita by End-Use Sector during 1960-2006.

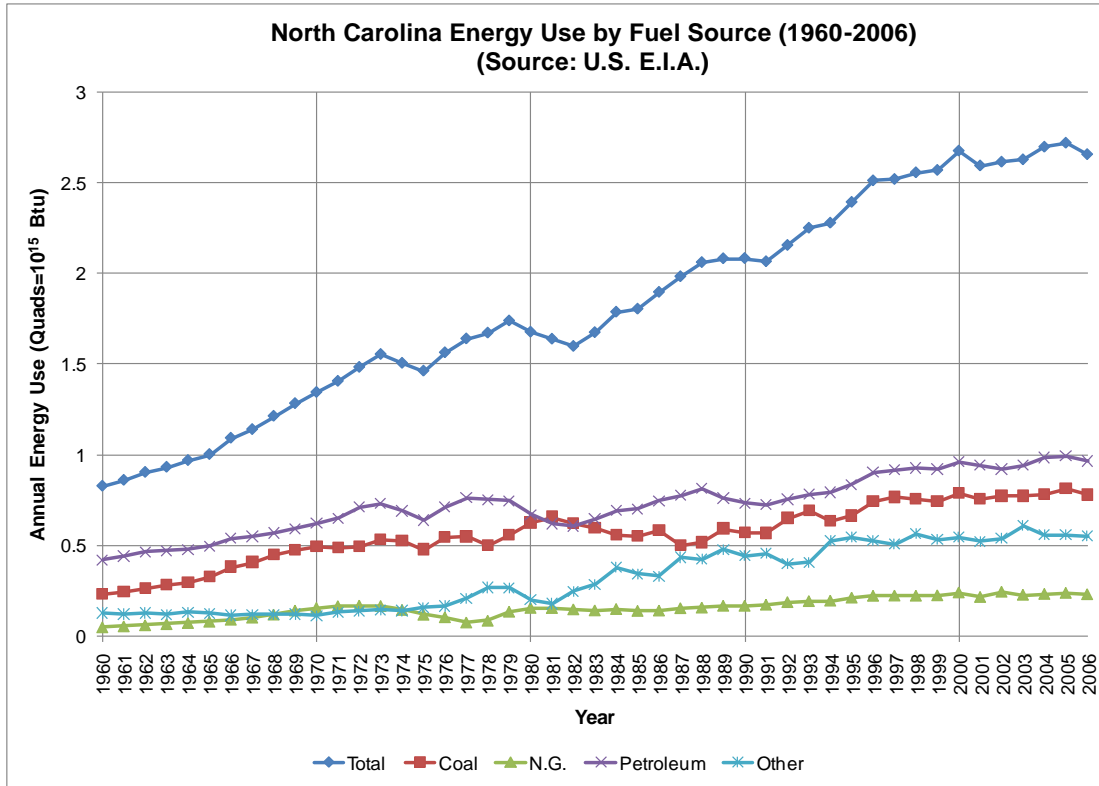


Figure 4.9.3. North Carolina Energy Use by Fuel Source during 1960-2006.

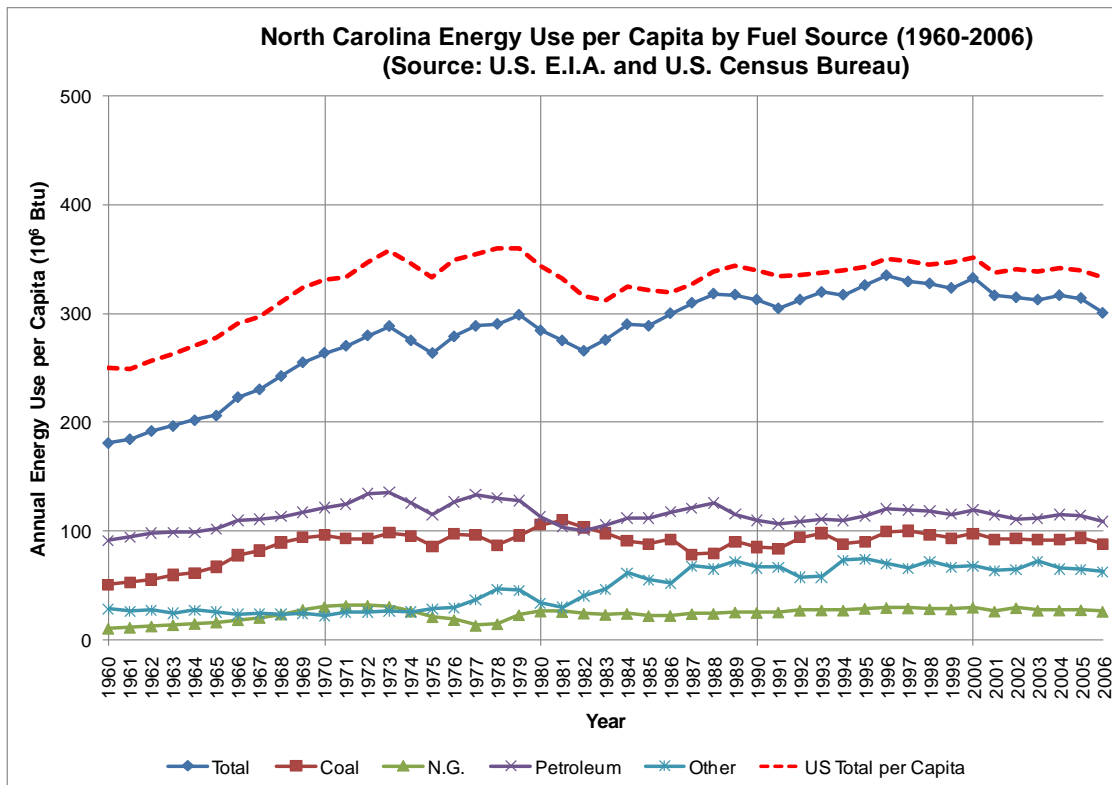


Figure 4.9.4. North Carolina Energy Use per Capita by Fuel Source during 1960-2006.

4.10 Oklahoma

Figure 4.10.1 and Figure 4.10.2, respectively, show the total and per capita energy use of Oklahoma by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.10.3 and Figure 4.10.4, respectively, show the total and per capita energy use of Oklahoma by fuel source during the period of 1960 to 2006. Oklahoma's energy use, both total and per capita, has been slightly increasing and per capita energy use has remained constant since 1980, keeping little fluctuation. Oklahoma's energy use per capita is still beyond the U.S. average per capita. Both the electric power and the industrial sectors were the largest consuming sectors among end-use sectors, followed by transportation, residential and commercial. By fuel source, the energy consumption of both natural-gas-based and petroleum-based products occupied the largest proportion of the total, followed by coal and other fuel sources. It is noticeable that Oklahoma's energy consumption of other fuel source products is constantly little, and in the early 1980's, there was sudden increase of coal-based products' energy consumption.

The total population and energy use information for Oklahoma in 2006 is as follows:

- Oklahoma Total Population (2006): 3,568,132
- Oklahoma Total Energy Use (Quads= 10^{15} Btu, 2006): 1.60 Quads

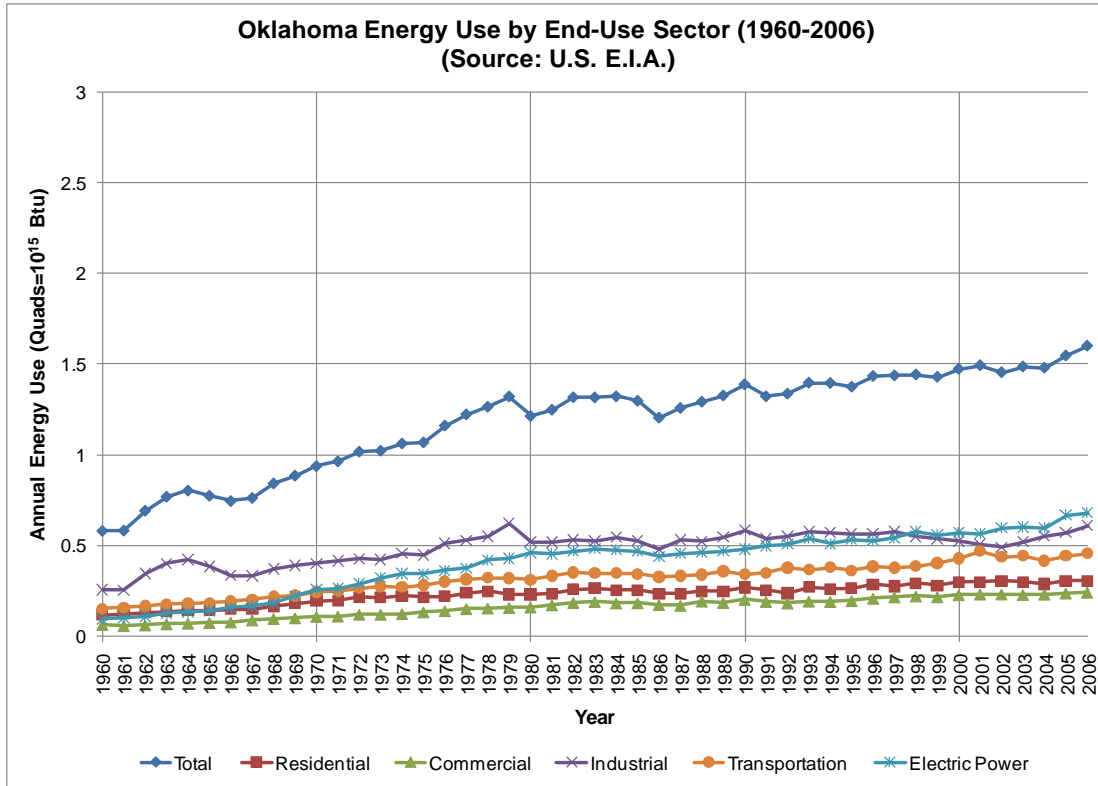


Figure 4.10.1. Oklahoma Energy Use by End-Use Sector during 1960-2006.

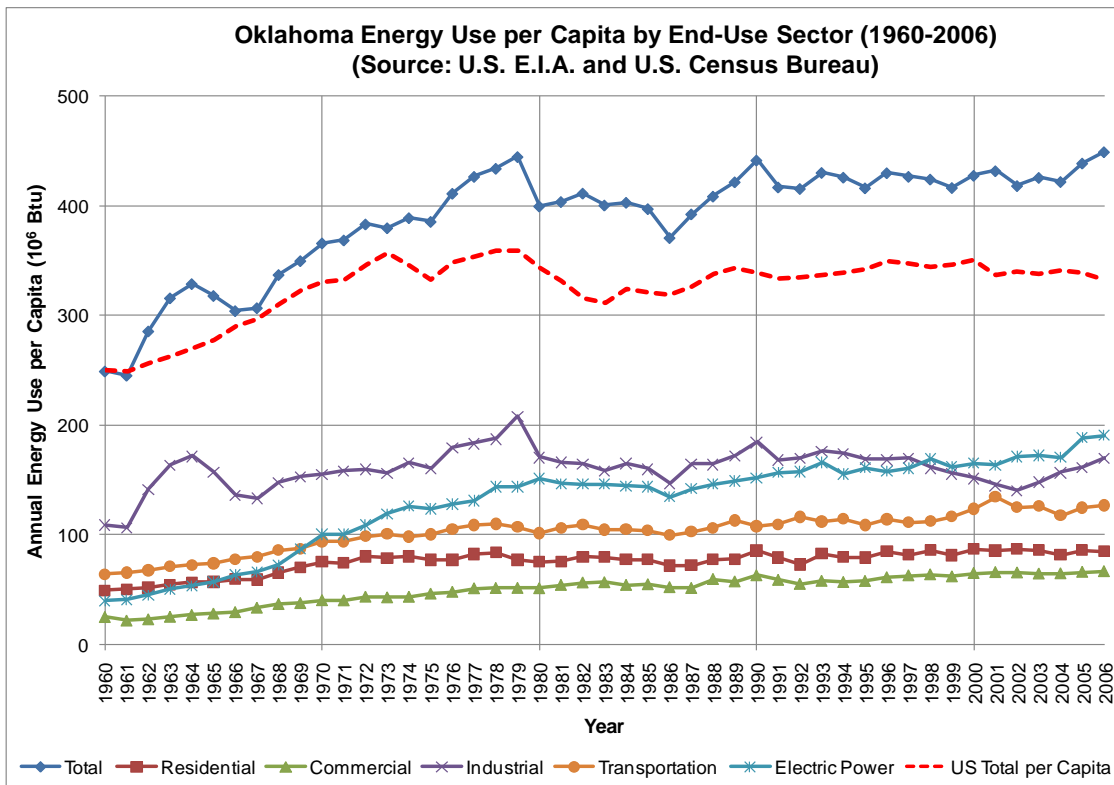


Figure 4.10.2. Oklahoma Energy Use per Capita by End-Use Sector during 1960-2006.

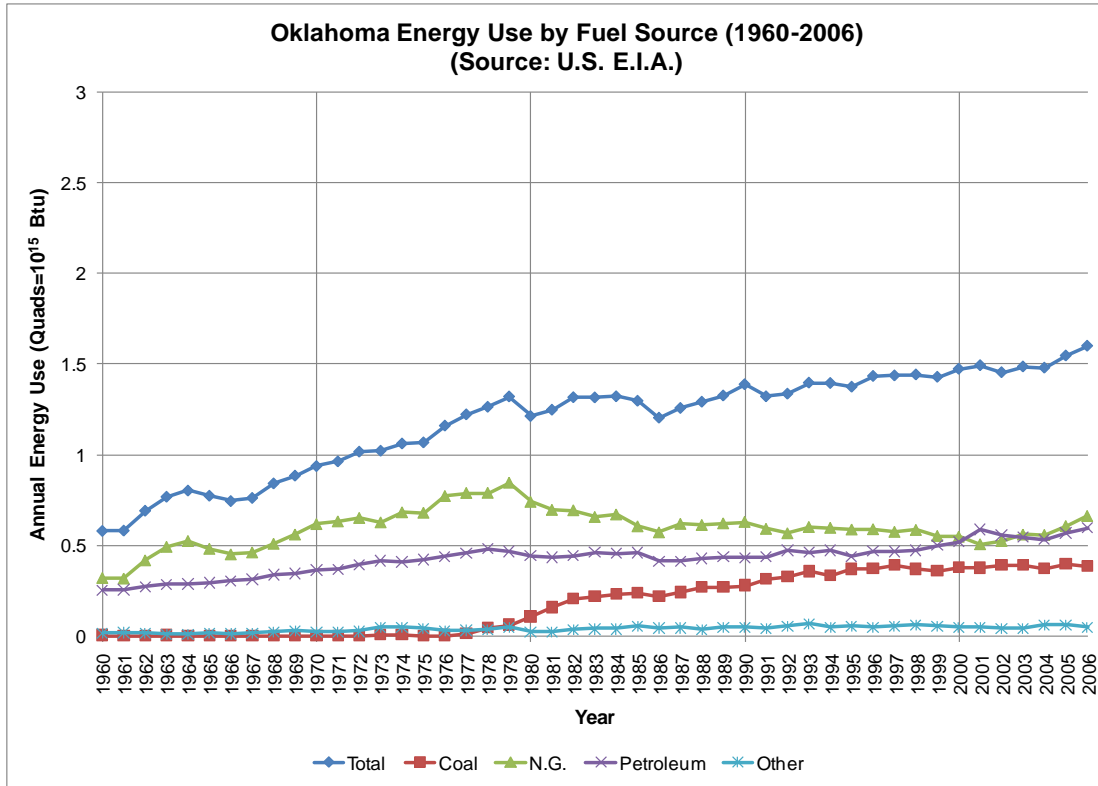


Figure 4.10.3. Oklahoma Energy Use by Fuel Source during 1960-2006.

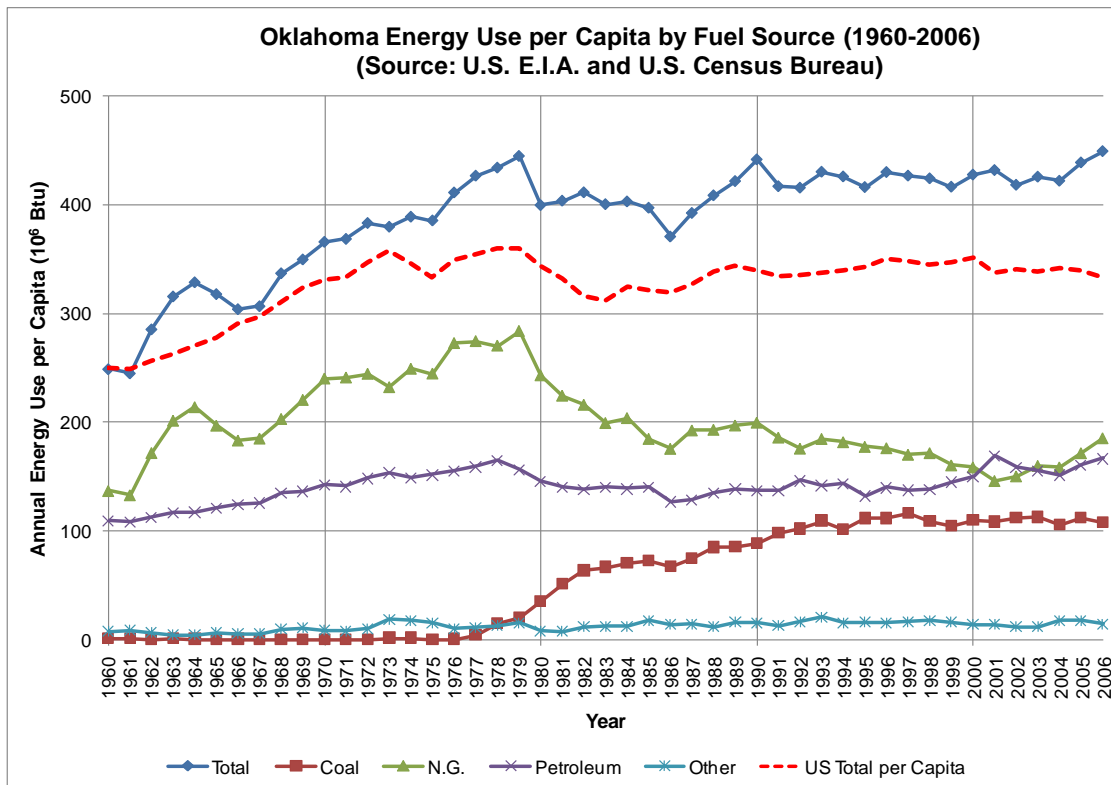


Figure 4.10.4. Oklahoma Energy Use per Capita by Fuel Source during 1960-2006.

4.11 South Carolina

Figure 4.11.1 and Figure 4.11.2, respectively, show the total and per capita energy use of South Carolina by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.11.3 and Figure 4.11.4, respectively, show the total and per capita energy use of South Carolina by fuel source during the period of 1960 to 2006. South Carolina's energy use, both total and per capita, has been continuously increasing and per capita energy use has remained constant since 1980, keeping little fluctuation. South Carolina's energy use per capita has started beyond the U.S. average per capita since the middle 1980's. The electric power sector consumed the largest amount of total energy among end-use sectors, followed by industrial, transportation, residential and commercial. By fuel source, the energy consumption of products based on the other fuel sources occupied the largest proportion of the total, followed by petroleum, coal, and natural gas. There were little differences between other fuel sources and petroleum. It is noticeable that South Carolina's energy consumption of other fuel source products is the highest among fuel sources since the middle 1980's.

The total population and energy use information for South Carolina in 2006 is as follows:

- South Carolina Total Population (2006): 4,324,799
- South Carolina Total Energy Use (Quads= 10^{15} Btu, 2006): 1.71 Quads

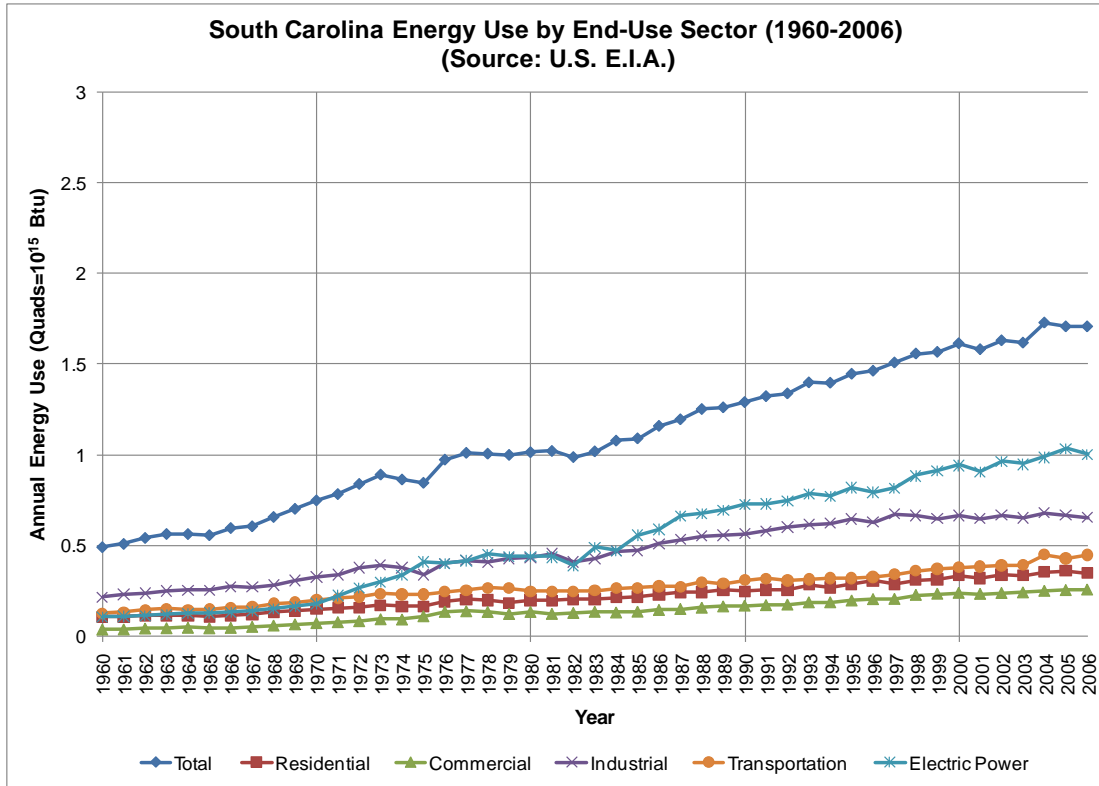


Figure 4.11.1. South Carolina Energy Use by End-Use Sector during 1960-2006.

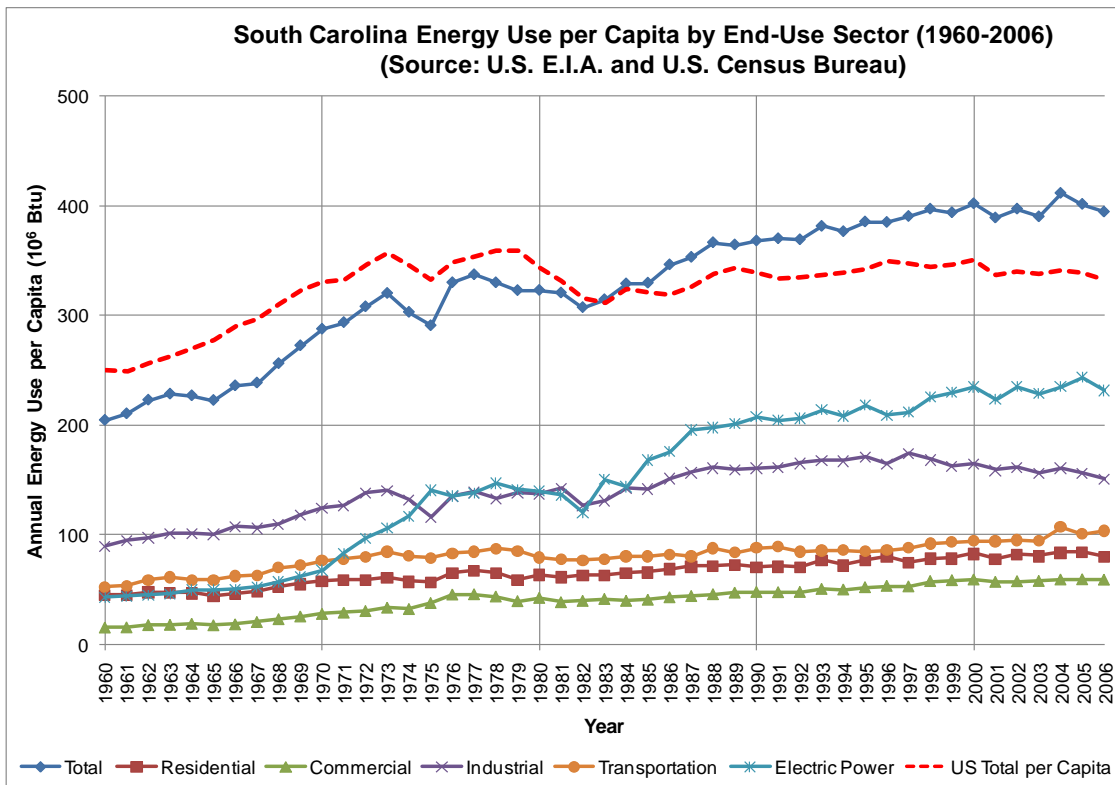


Figure 4.11.2. South Carolina Energy Use per Capita by End-Use Sector during 1960-2006.

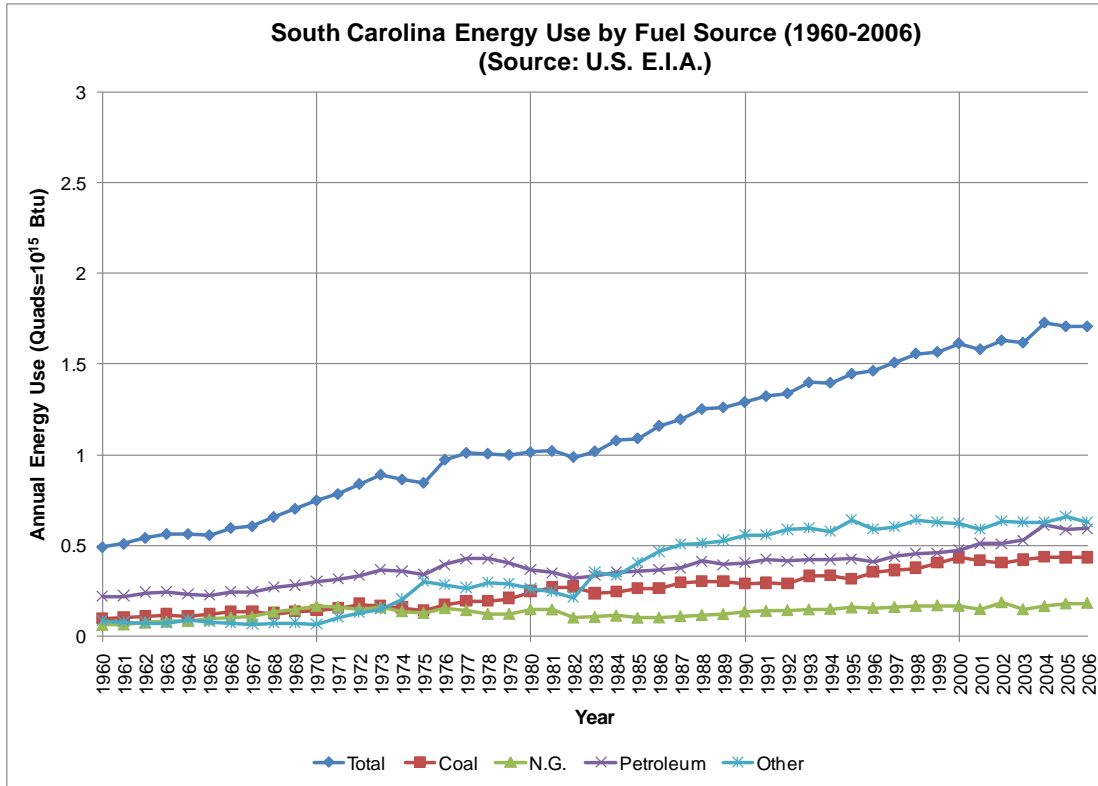


Figure 4.11.3. South Carolina Energy Use by Fuel Source during 1960-2006.

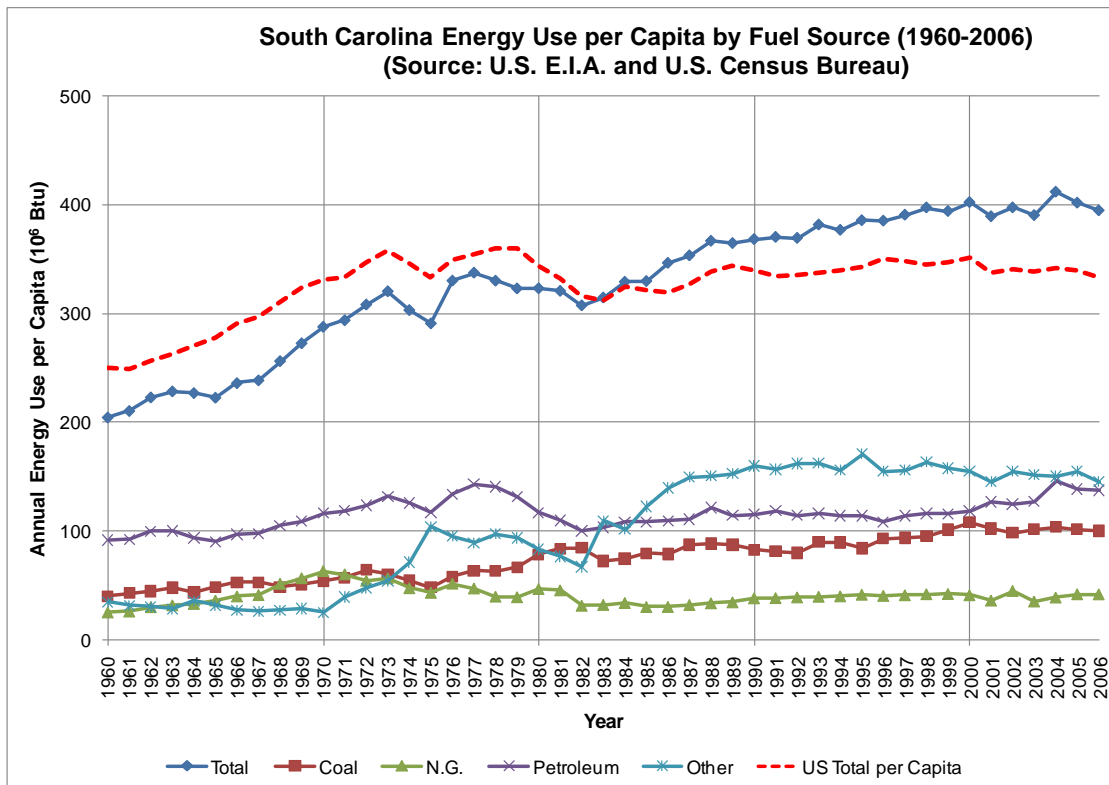


Figure 4.11.4. South Carolina Energy Use per Capita by Fuel Source during 1960-2006.

4.12 Tennessee

Figure 4.12.1 and Figure 4.12.2, respectively, show the total and per capita energy use of Tennessee by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.12.3 and Figure 4.12.4, respectively, show the total and per capita energy use of Tennessee by fuel source during the period of 1960 to 2006. Tennessee's total energy use has been continuously rising while per capita energy use has remained constant since the middle 1970's. Tennessee's energy use per capita is slightly higher than the U.S. average per capita. The electric power sector consumed the largest amount of total energy among end-use sectors, followed by industrial, transportation, residential and commercial. It is noticeable that there was sudden increase of commercial sector's energy consumption in the middle 1980's, while the industrial sector's energy consumption suddenly dropped during the same period. By fuel source, the energy consumption of petroleum-based products occupied the largest proportion of the total, followed by coal, other fuel sources, and natural gas. There were little differences between petroleum-based and coal-based products.

The total population and energy use information for Tennessee in 2006 is as follows:

- Tennessee Total Population (2006): 6,068,306
- Tennessee Total Energy Use (Quads= 10^{15} Btu, 2006): 2.31 Quads

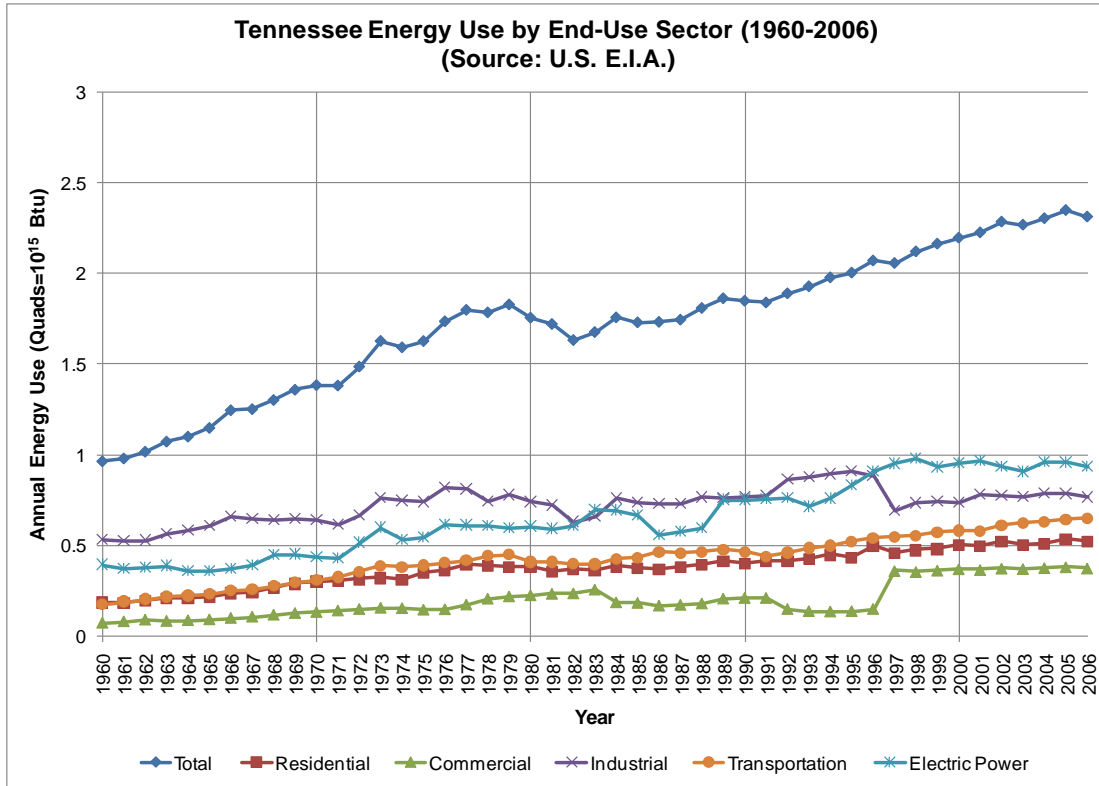


Figure 4.12.1. Tennessee Energy Use by End-Use Sector during 1960-2006.

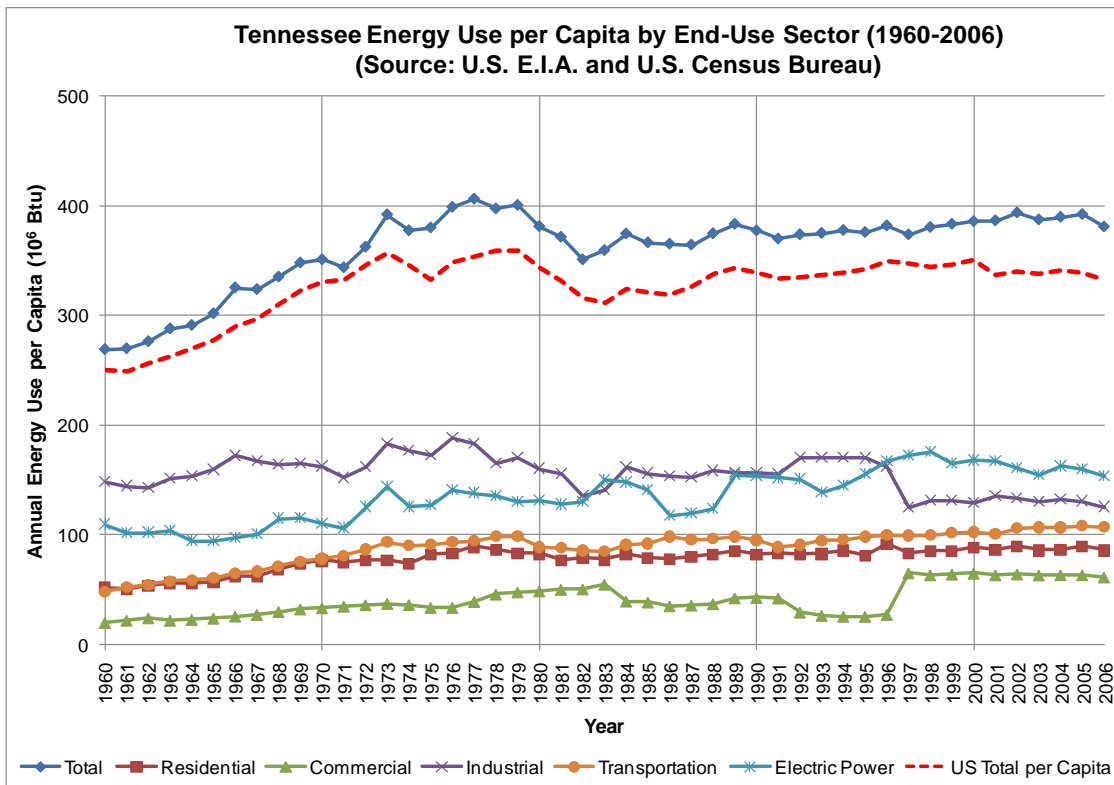


Figure 4.12.2. Tennessee Energy Use per Capita by End-Use Sector during 1960-2006.

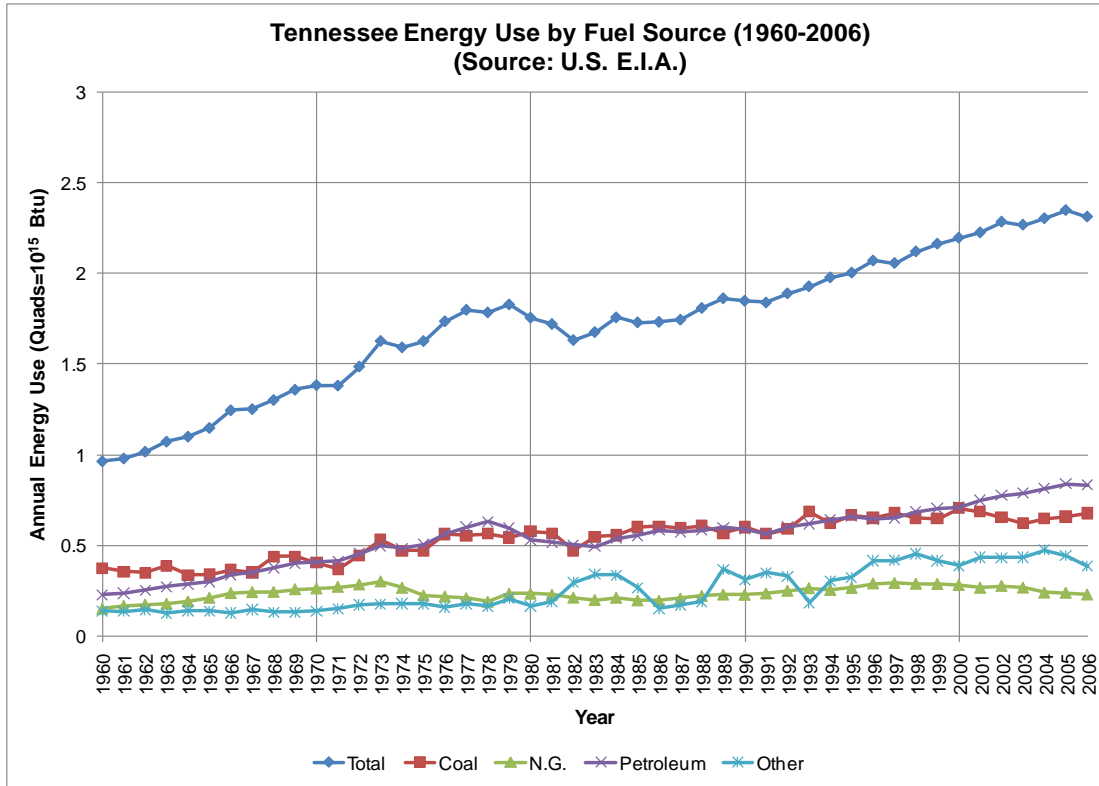


Figure 4.12.3. Tennessee Energy Use by Fuel Source during 1960-2006.

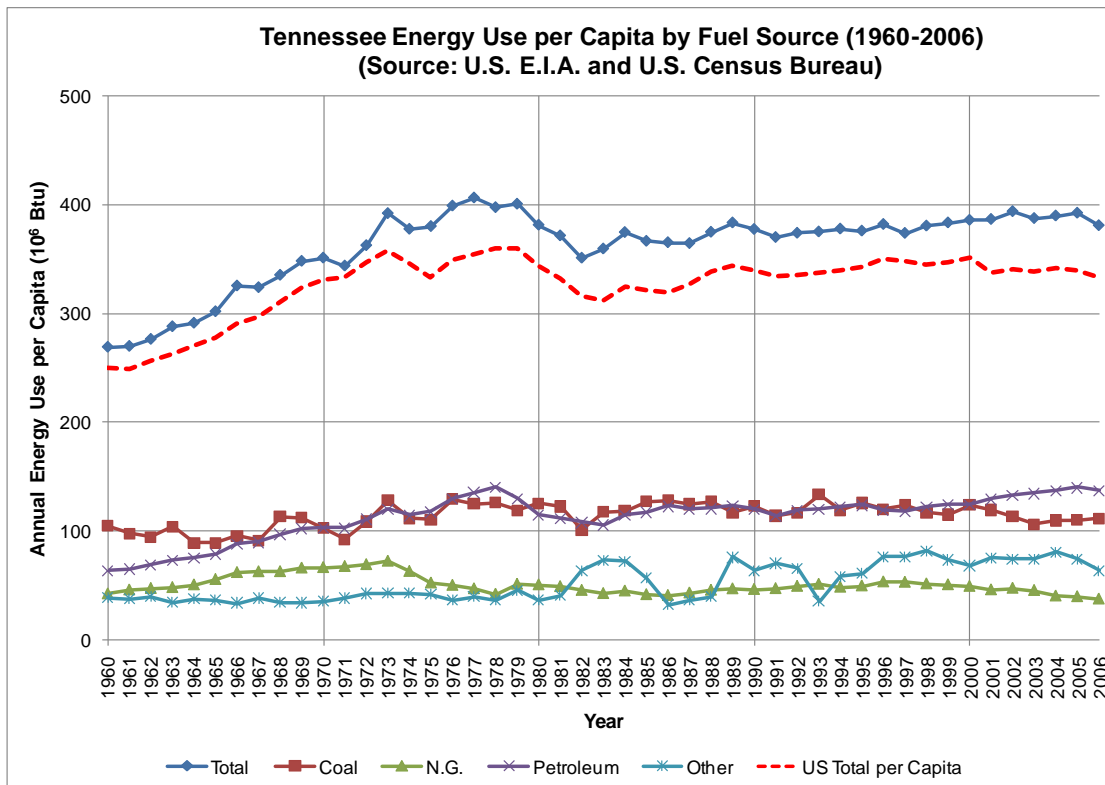


Figure 4.12.4. Tennessee Energy Use per Capita by Fuel Source during 1960-2006.

4.13 Texas

Figure 4.13.1 and Figure 4.13.2, respectively, show the total and per capita energy use of Texas by the end-use sector during the period of 1960 to 2006. Figure 4.13.3 and Figure 4.13.4, respectively, show the total and per capita energy use of Texas by fuel sources during the period of 1960 to 2006. Texas's total energy use has been continuously rising while per capita energy use has remained constant, although since 2000, per capita energy use in Texas has started decreasing. Texas's energy use per capita is still far beyond the U.S. average per capita. The industrial sector consumed the largest amount of total energy among end-use sectors, followed by electric power, transportation, residential and commercial. By fuel source, the energy consumption of petroleum-based products occupied the largest proportion of total, followed by natural gas, coal, and other fuel sources. It is noticeable that the energy consumption of natural gas products has suddenly decreased since 2004.

The total population and energy use information for Texas in 2006 is as follows:

- Texas Total Population (2006): 23,367,534
- Texas Total Energy Use (Quads= 10^{15} Btu, 2006): 11.74 Quads

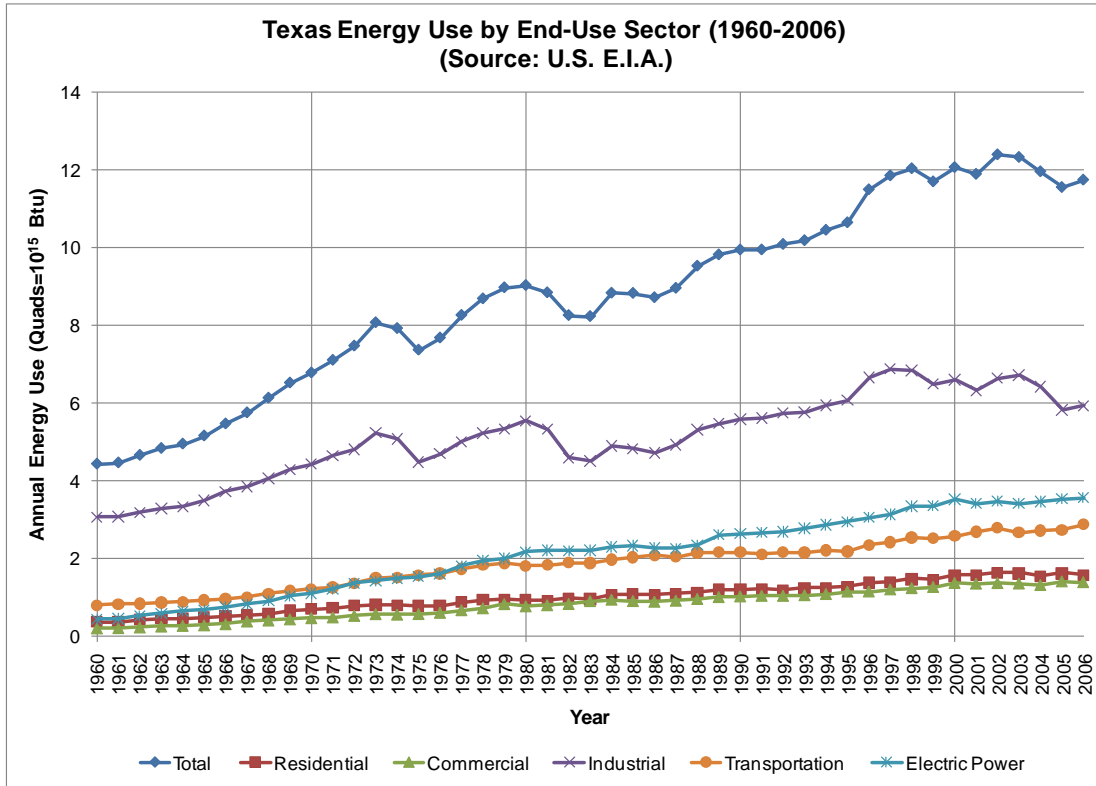


Figure 4.13.1. Texas Energy Use by End-Use Sector during 1960-2006.

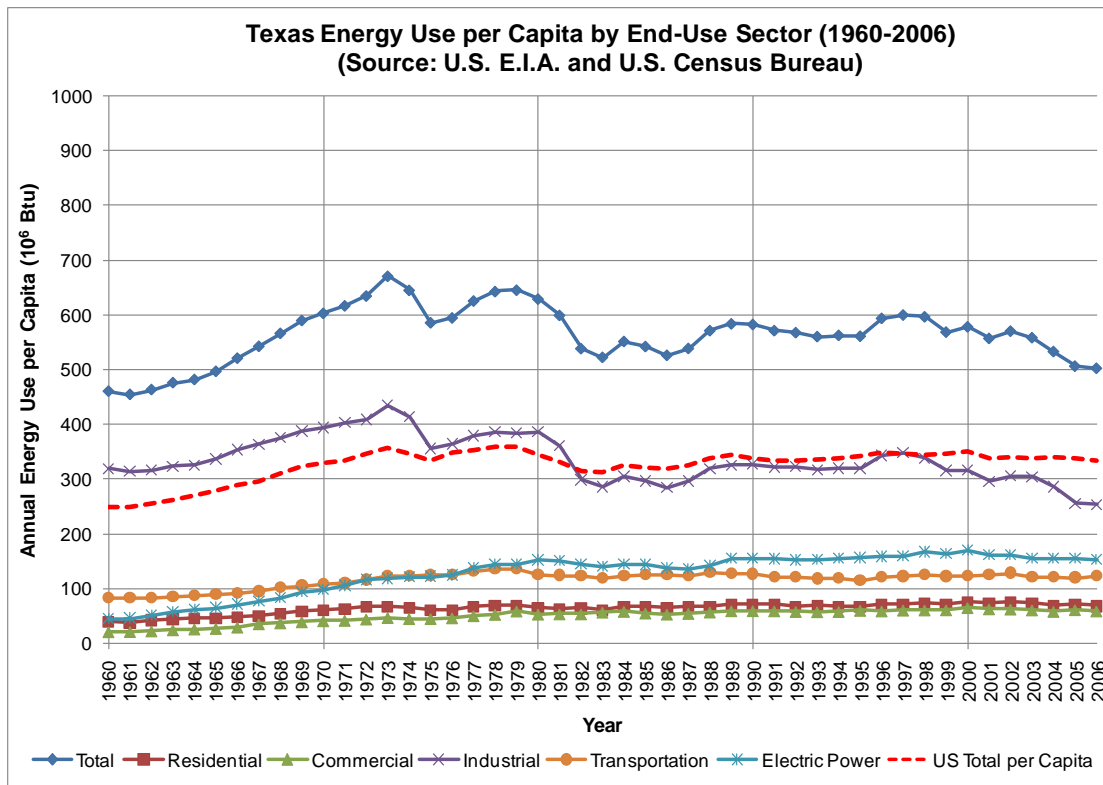


Figure 4.13.2. Texas Energy Use per Capita by End-Use Sector during 1960-2006.

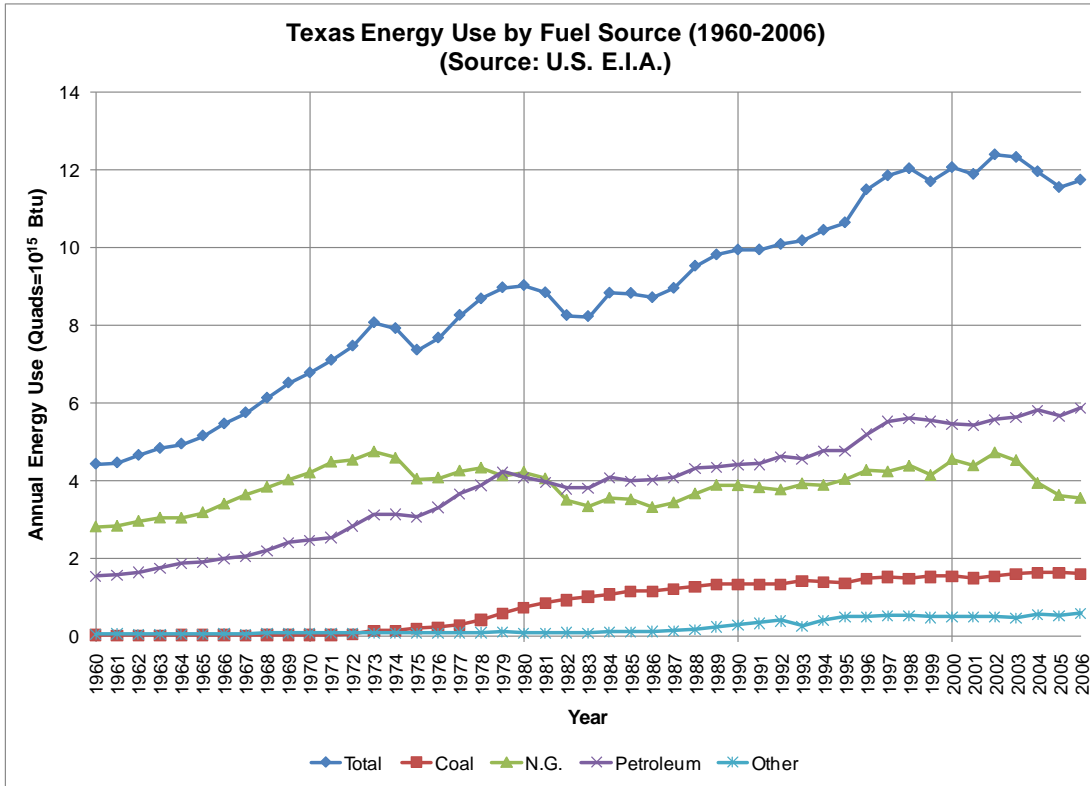


Figure 4.13.3. Texas Energy Use by Fuel Source during 1960-2006.

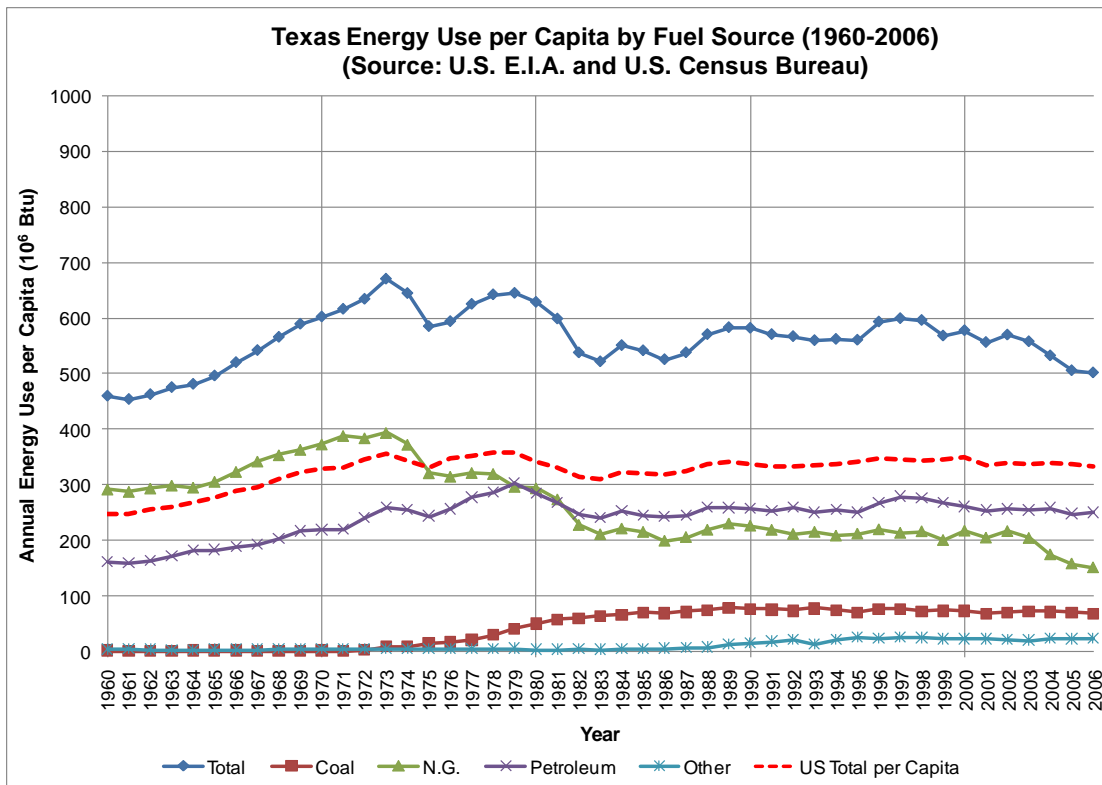


Figure 4.13.4. Texas Energy Use per Capita by Fuel Source during 1960-2006.

4.14 Virginia

Figure 4.14.1 and Figure 4.14.2, respectively, show the total and per capita energy use of Virginia by end-use sector (residential, commercial, industrial and transportation) and electric power sector during the period of 1960 to 2006. Figure 4.14.3 and Figure 4.14.4, respectively, show the total and per capita energy use of Virginia by fuel source during the period of 1960 to 2006. Virginia's total energy use has been continuously rising while per capita energy use has remained constant. Virginia's energy use per capita has been approaching the U.S. average per capita, while keeping slightly less than the average. Since 2004, it has started fluctuating around the average. Both the electric power and the transportation sectors were the largest consuming sectors among end-use sectors, immediately followed by next group that consists of residential, commercial, and industrial. By fuel source, the energy consumption of petroleum-based products distinctly occupied the largest proportion of the total. There were little differences between coal and other fuel source products, and natural gas occupied the smallest proportion.

The total population and energy use information for Virginia in 2006 is as follows:

- Virginia Total Population (2006): 7,628,347
- Virginia Total Energy Use (Quads= 10^{15} Btu, 2006): 2.54 Quads

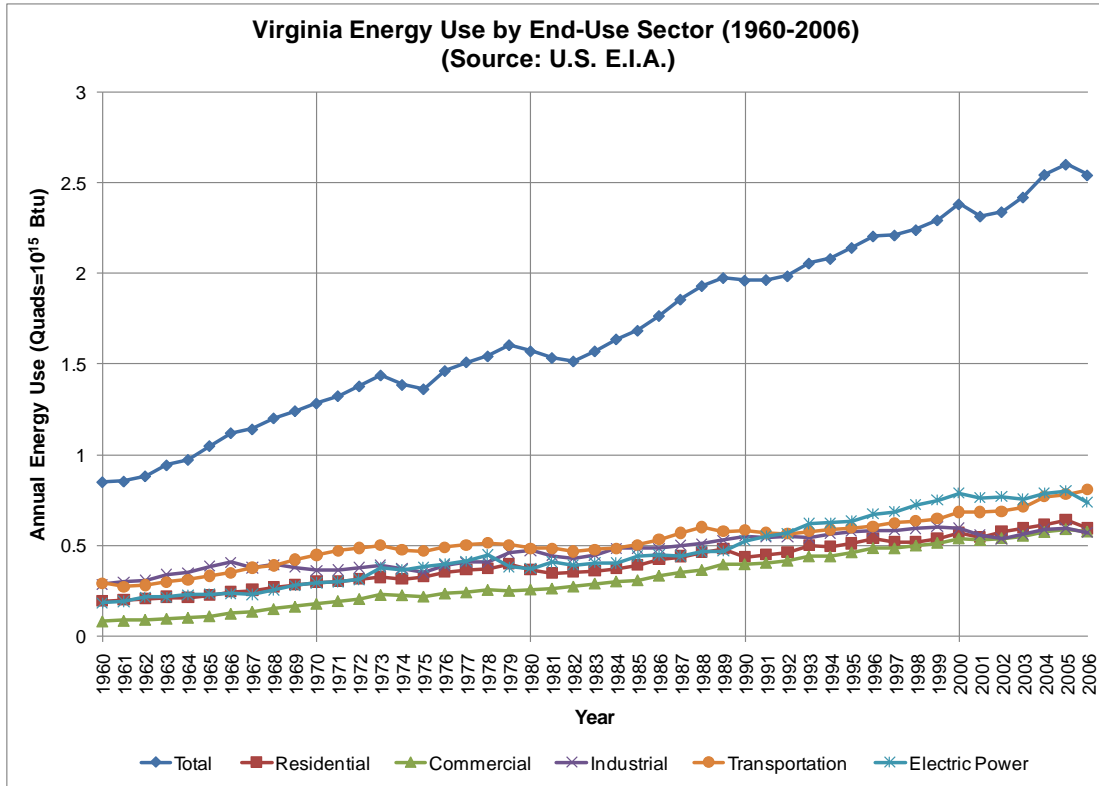


Figure 4.14.1. Virginia Energy Use by End-Use Sector during 1960-2006.

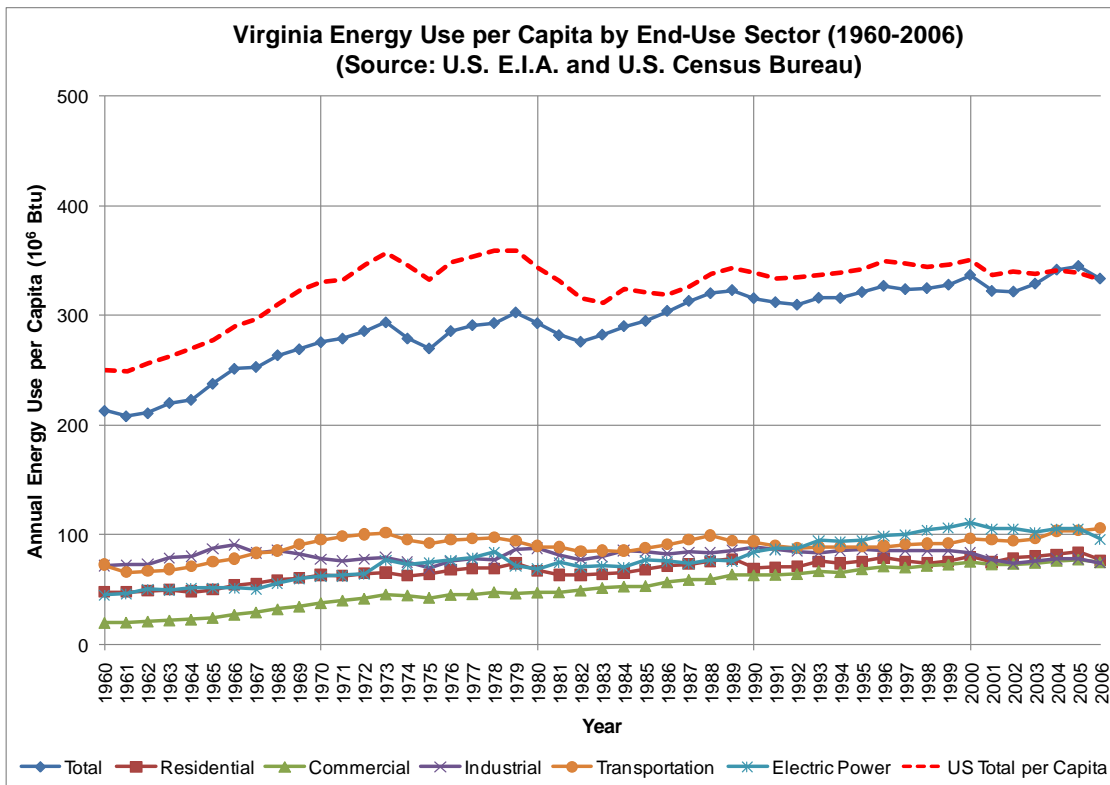


Figure 4.14.2. Virginia Energy Use per Capita by End-Use Sector during 1960-2006.

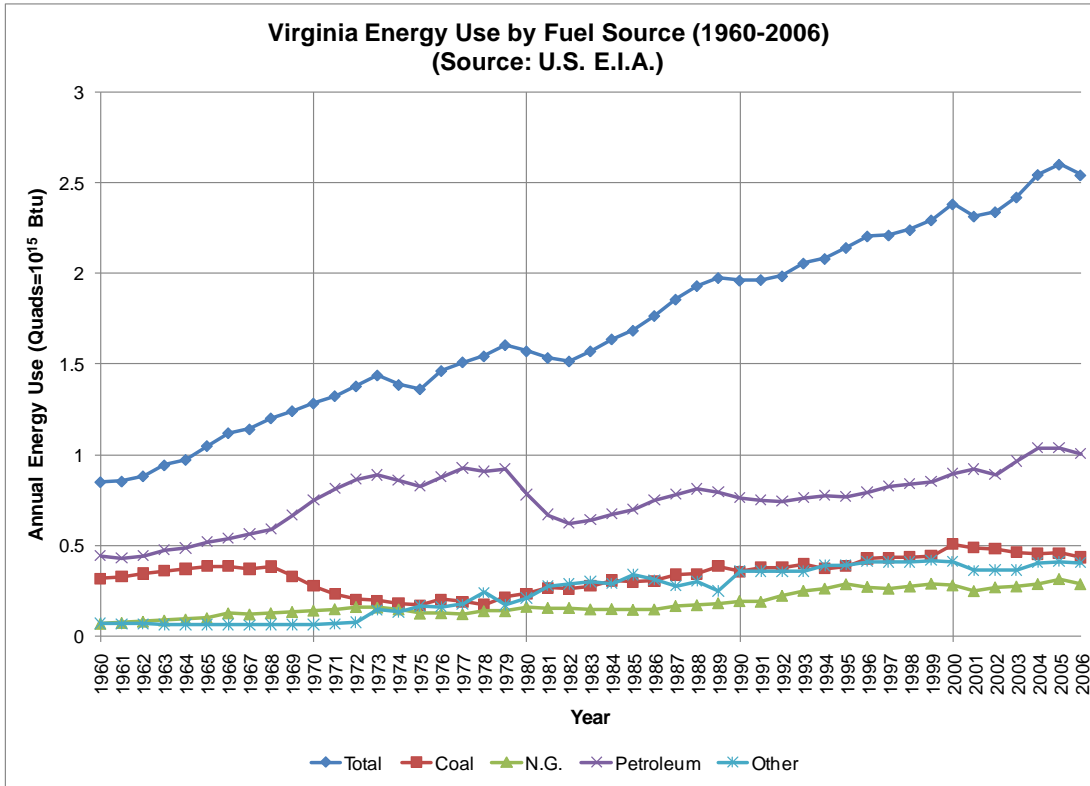


Figure 4.14.3. Virginia Energy Use by Fuel Source during 1960-2006.

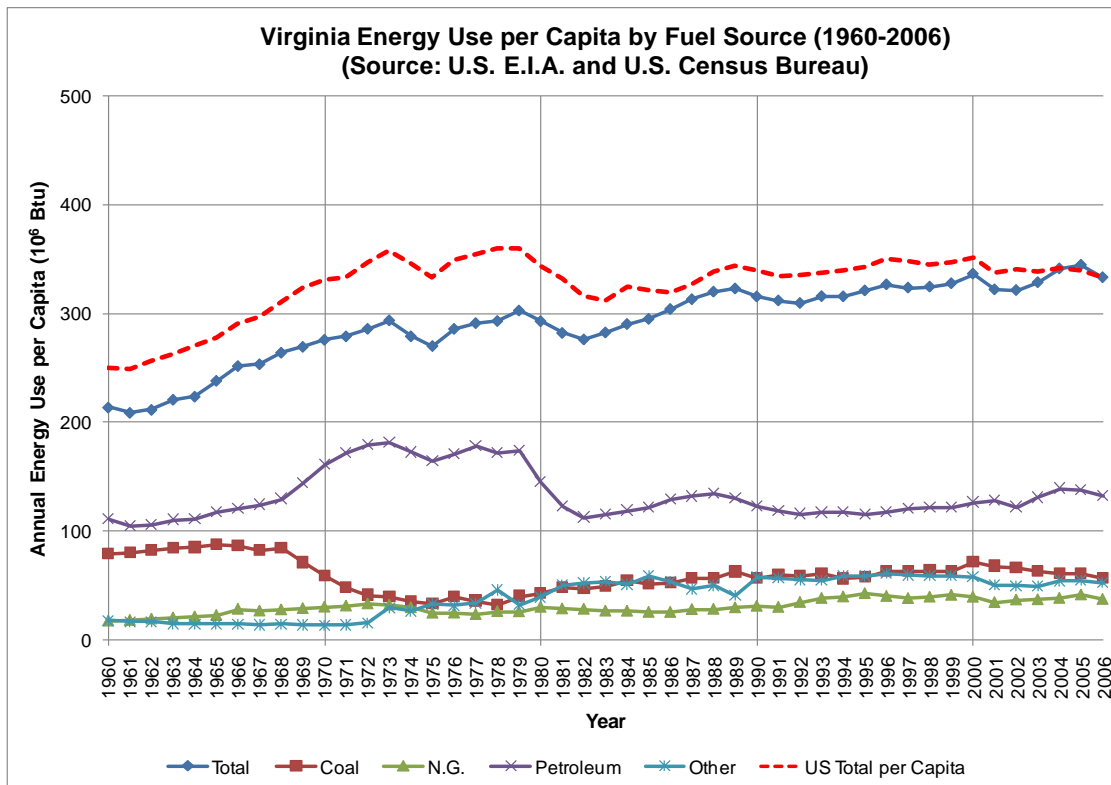


Figure 4.14.4. Virginia Energy Use per Capita by Fuel Source during 1960-2006.

5 ASHRAE/CIBSE/USGBC Performance Measurement Protocols for Commercial Buildings

5.1 Overview

This section contains the summary of the energy section of the ASHRAE/CIBSE/USGBC Performance Measurement Protocols (PMP) for Commercial Buildings, including the descriptions of the three-level measurement methods. The energy section of the protocols applies to all forms of energy, including: electricity, gas, oil, district heating/cooling, and renewable. Because the protocols target an individual building or facility, this bottom-up approach can be used for energy efficiency improvements of buildings within the SEEC 12-state region.

The purpose of the ASHRAE/CIBSE/USGBC Performance Measurement Protocols (PMP) for Commercial Buildings is to provide a standardized set of protocols for the operational performance measurement of occupied commercial buildings including: energy use, water use, and indoor environmental quality. The protocols identify what is to be measured, how it is to be measured (instrumentation and spatial resolution), and how often it is to be measured. For each of these measured characteristics, protocols have been developed at three levels (Basic [Indicative], Intermediate [Diagnostic], and Advanced [Investigative]) of cost/accuracy, providing realistic choices for consistent performance characterization of the building stock, and comparison to appropriate benchmarks.

Section 5.2 summarizes the introduction and background of the energy section of the protocols. Section 5.3 to 5.5 provide the descriptions of the Basic (Level 1), Intermediate (Level 2) and Advanced (Level 3) Energy Protocols, respectively.

5.2 Introduction and Background

According to the protocols, the ability to measure and determine baseline energy use and desirable building energy performance improvements is essential to verification of that performance. Protocols are presented that cover measurement of energy use and energy performance determination and diagnostics at three levels of rigor, complexity, and cost. The basic methods provide medium accuracy results but are fast and simple to use. The intermediate and advanced levels are intended to improve accuracy and understanding of energy performance but take more time, are more complicated, and are more costly.

These protocols are directed towards operational ratings and improvement to those ratings.

a) Basic Level

- The basic level requires measurement of energy use by fuel type, collection of basic building characteristics data, measurement of total annual energy use and peak demand, and comparison to as many national or international norms or rating scales as feasible or useful.
- The basic level results of this guide will be a “grade” or grades, which for the United States will usually be a ranking score or percentile score from 1–100. A rank or “grade” of 40–60 is “typical” for US methods. Users must decide based on their building “grade” whether they wish to improve or not. The basic level is intended to determine the “grade(s)” obtained and compilation of basic energy use and characteristics data.

b) Intermediate and Advanced Level

- The intermediate and advanced methods require monthly and weekly performance determination updates, respectively. In addition, the intermediate and advanced methods introduce system performance determination methods that allow causes of poor performance that are not self-evident to be understood and assessed.
- The intermediate and advanced levels require determination of the “grade(s)” achieved at increasing frequency (monthly update for intermediate and daily for advanced). In addition, these levels provide increasingly sophisticated methods for assessing and diagnosing causes of less than desirable energy performance, as well as evaluation of potential causes of any slips in performance over time. Full implementation of the basic level should be completed before users proceed. Partial implementation of intermediate and advanced levels is allowable and may even be desirable at times.

5.3 Basic (Level 1) Energy Protocols

Objective

The objectives of basic methods are to:

- Provide the foundation for characterizing and understanding building energy performance; this basic performance should be determined for all buildings.

Measurement Methods

Basic data collection and baseline(s) development will typically require expenditures of \$1,000-2,000.

Required data are of three types:

- Basic building characteristics needed for performance expression and comparison;
- Annual whole-building energy use and costs of all electricity and fuels used, including the (highest) annual peak demand for each fuel (or all peak demand values and dates for a year), if shown on utility bills (if not reported by the utility, demand reporting is not required); and
- Annual energy and cost indices (per unit area of the building).

Metrics

Measured site energy use and energy cost for all forms of energy over a period of 12 consecutive months (365 days, annual total) must be reported. Metered energy use is required for all utility-supplied fuels, although some estimates may be necessary for bulk fuels like coal or oil. The source of data for each energy form must be specified using the following categories:

- Utility bill or meter;
- Non-utility installed meter or sub-meter;
- Estimate (to be used only to fill in brief gaps in data and requires a brief description); and
- Other (requires a brief explanation).

Performance Evaluation/Benchmarking

Energy performance ratings and benchmark comparisons are less detailed and provide much less information regarding potential causes of specific energy performance. Instead, what is provided is an appropriate indication of overall energy performance compared to other similar buildings. Performance rating can be done in many ways including:

- Energy Star performance rating;
- Special purpose rating tools developed from some entities, such as California and New York;
- European ratings;
- Reference building comparison for the countries where specific reference buildings have been documented to provide an energy benchmark comparison method;
- Building type Energy Use Index (EUI) comparison; and
- Cost Index Comparison.

Buildings not covered by other methods for reporting performance comparisons should report the applicable EUI percentile values. For the basic level, annual data for at least a three-year period is desirable, preferably. The first performance rating obtained is the baseline. Improvement targets should be set relative to the baseline performance “grade.” Energy assessments may be needed if performance improvements are desired.

5.4 Intermediate (Level 2) Energy Protocols

Objective

Intermediate methods build on the basic annual energy use data and associated EUIs and ECIs by going deeper into monthly and weekly data for the whole building and for major energy end uses. At this level major end use breakdowns are determined through data analysis. The objectives of the intermediate methods are to:

- Provide measurement and evaluation methods that support an enhanced level of understanding of building and end use performance so as to identify possible areas of performance improvement.

Measurement Methods

Intermediate instrumentation and analysis to determine this level of performance will cost in the range of \$2,000 to \$10,000. Required data is:

- All Basic results; and
- Monthly and weekly whole-building and major end-use energy use and costs of all electricity and fuels used, including the (highest) monthly electrical demand.

Metrics

While the Basic (Level 1) data focus is on annual energy use, the Intermediate (Level 2) data addresses monthly and weekly (occupied vs. unoccupied periods) energy data. Furthermore while the Basic data focus on whole-building energy use, the Intermediate level of this guide begins to incorporate the systems-level (energy end use) effects. Another difference is that Level 1 focuses on benchmarking against norms or with rating tools, whereas in Level 2 the focus is on performance improvement through self-reference energy use benchmarks of the whole building, building systems, or occupancy periods.

The use of advanced metering systems and data-tracking tools, even on a partial systems basis, can be useful in supporting these assessments and performance tracking. The use of log books or daily logs (manual reading of meters) can also support such efforts. The metrics of Intermediate data analysis includes:

- Electrical Load Factor (monthly) comparison against Occupant Load Factor (OLF); and
- End-Use Assessment.

Performance Evaluation/Benchmarking

As a supplement to end use sub-metering, whole-building inverse energy use models are important options for improving understanding of the end-use breakouts of heating, cooling, and base load energy use. These models usually involve the use of a regression model that relates the energy use and/or peak demand to one or more independent variables. The most widely accepted technique uses linear or change-point linear regression to correlate energy use or peak demand as the dependent variable with weather data and/or other independent variables.

This approach can be used to characterize the daily-average heating, cooling, and base load energy use for each month by plotting energy use vs. outdoor temperature for the heating and cooling seasons, as is illustrated in the example below. The model serves as a self-reference, whole-building energy use benchmark to compare against a later model of the same energy after any efficiency improvements are made. A new model can show the efficiency improvements relative to the initial benchmark and can be used to calculate energy savings.

5.5 Advanced (Level 3) Energy Protocols

Objective

The objectives of the advanced methods are to:

- Track energy performance daily or hourly, for whole building and through sub-metered data;
- Identify additional potential improvements that will increase performance;
- Possibly develop advanced models of building performance; and
- Verify performance improvements relative to self-reference benchmarks and calculate energy savings achieved in greater detail.

Measurement Methods

Because of the extensive instrumentation and sophisticated analytical techniques required, advanced performance evaluation is quite costly (\$10,000-100,000 per building) and would be used only on a small fraction (less than 1%) of the building stock. Required data is:

- All Basic and Intermediate results; and
- Daily whole-building energy use and costs of all electricity and fuels used.
- Daily major end-use energy use and costs of all electricity and fuels used, either modeled or measured.

Metrics

Metrics include both daily generation of performance ratings using rating tools or comparisons against norms, and generation of more advanced self-reference energy-use benchmark models using more detailed data. The self-reference benchmarks at the Advanced level typically derive from a combination of detailed measured data (daily or hourly) and models that establish weather and non-weather sensitive energy use. Generation of these daily basis benchmark models allows the weekday and weekend/holiday patterns to be differentiated, and improved identification of targeted energy saving opportunities is also possible.

The self-reference benchmark models are typically based on one of the two basic approaches including:

- Whole-building calibrated simulations; and
- Inverse building and system models.

Performance Evaluation/Benchmarking

The important results to be reported for the whole-building model results are:

- Equations for calculating weather-normalized total energy use;
- Coefficient values of any equation parameters;
- Estimated heating, cooling, and base load energy use for specific weather years; and
- Goodness-of-fit parameters for the model equations.

Reporting of monthly updates of the annual (latest 12-month) performance comparisons is also required. To determine savings for system and component evaluation (Retrofit Isolation), the procedures in the ASHRAE's Guideline 14-2002 can be followed. This guideline contains retrofit isolation procedures for the measurement and verification of savings (which also treats baseline energy use measurement) of systems and/or components such as pumps, fans, chillers, boilers and furnaces, lighting, as well as large and unitary HVAC systems. To establish energy savings relative to baseline energy use, they use benchmarks of either sampled before/after measurements or sub-metered before-after measurements.

APPENDIX A. Energy Consumption Data.

Appendix A presents the detailed information of energy consumption data sets that have been used for this subtask, including the source, selected data codes, and term definitions. The energy consumption data used for the SEEC subtask 3.1 to define regional energy baseline is taken from the U.S. DOE EIA's State Energy Data System (SEDS) website.

- Energy Consumption Data Sources:
 U.S. DOE, EIA. 2008. *Consumption, Price, and Expenditure Estimates through 2006: Complete Data Files, All States and All Years*, State Energy Data System (SEDS), Energy Information Administration, U.S. Department of Energy, Retrieved from <http://www.eia.doe.gov/emeu/states/seds.html> (accessed February 2, 2009).
- 2006 is the latest year for which state-by-state energy consumption data is available. Among 276 data codes, the selected data codes are presented in Table A.1. The EIA definitions of several terms, which are specific to this report, are presented in Table A.2.
- A new data series “Other” (Other Fuel Source), including nuclear electric power, hydro-electric power, biomass, geothermal, wind, photovoltaic, solar thermal energy, and net imports of electricity, has been defined to display annual energy consumption by fuel source using the following equation:

$$\text{Other} = \text{TETCB} - \text{CLTCB} - \text{NNTCB} - \text{PATCB} - \text{ELISB}$$
 where:
 - TETCB: Total energy consumed.
 - CLTCB: Coal total consumed.
 - NNTCB: Natural gas total consumed.
 - PATCB: All petroleum products total consumed.
 - ELISB: Net interstate sales of electricity and associated losses.
- For the natural gas based energy consumption, “NNTCB” (Natural gas total consumed [excluding supplemental gaseous fuels]) was used instead of “NGTCB (Natural gas total consumed [including supplemental gaseous fuels])” because NGTCB is no longer published.

Table A.1. Selected Energy Consumption Data Codes

MSN	Description	Unit
TETCB	Total energy consumed.	Billion Btu
TERCB	Total energy consumed by the residential sector.	Billion Btu
TECCB	Total energy consumed by the commercial sector.	Billion Btu
TEACB	Total energy consumed by the transportation sector.	Billion Btu
TEICB	Total energy consumed by the industrial sector.	Billion Btu
TEEIB	Total energy consumed by the electric power sector.	Billion Btu
CLTCB	Coal total consumed.	Billion Btu
NNTCB	Natural gas total consumed (excluding supplemental gaseous fuels).	Billion Btu
PATCB	All petroleum products total consumed.	Billion Btu
ELISB	Net interstate sales of electricity and associated losses (negative and positive values).	Billion Btu

Table A.2. EIA Term Definitions

Term	Definition
Residential Sector	An energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a variety of other appliances. The residential sector excludes institutional living quarters.
Commercial Sector	An energy-consuming sector that consists of service-providing facilities and equipment of: businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a wide variety of other equipment. <i>Note:</i> This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments.
Transportation Sector	An energy-consuming sector that consists of all vehicles whose primary purpose is transporting people and/or goods from one physical location to another. Included are automobiles; trucks; buses; motorcycles; trains, subways, and other rail vehicles; aircraft; and ships, barges, and other waterborne vehicles. Vehicles whose primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles, and warehouse tractors and forklifts) are classified in the sector of their primary use. In this report, natural gas used in the operation of natural gas pipelines is included in the transportation sector.
Industrial Sector	An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity: manufacturing (NAICS codes 31-33); agriculture, forestry, fishing and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23). Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products. <i>Note:</i> This sector includes generators that produce electricity and/or useful thermal output primarily to support the above-mentioned industrial activities.
Electric Power Sector	An energy-consuming sector that consists of electricity-only and combined-heat-and-power (CHP) plants within the NAICS (North American Industry Classification System) 22 categories whose primary business is to sell electricity, or electricity and heat, to the public. <i>Note:</i> This sector includes electric utilities and independent power producers.

APPENDIX B. Population Data.

Appendix B presents the detailed information of population data sets that have been used for this subtask, including the source. The population data used for the SEEC subtask 3.1 to calculate per capita energy use is taken from the U.S. Census Bureau website. For the intercensal estimates of the total resident population of each state, the reference date is July 1 of each year. For the period of 1960 through 1999, the same data is also available in the U.S. DOE EIA's State Energy Data System (SEDS) website under the data code "TPOPP (Resident population including Armed Forces)." In this analysis, to reflect more recent estimation of the population, different data were used for the period of 2000 through 2008. The population estimation data from 2000 to 2008 are shown in Table B.1.

- Population Data Sources:

1960-1969: U.S. Department of Commerce, U.S. Census Bureau. 1996. *Intercensal Estimates of the Total Resident Population of States: 1960 to 1970*, State Population Estimates, 1900 to 1990, U.S. Census Bureau, Retrieved from <http://www.census.gov/popest/archives/1980s/st6070ts.txt> (accessed April 24, 2009).

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Table B.1. Population Estimates by States: 2000 through 2008.

Table 1: Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2008												
Geographic Area	Population Estimates										April 1, 2000	
	July 1, 2008	July 1, 2007	July 1, 2006	July 1, 2005	July 1, 2004	July 1, 2003	July 1, 2002	July 1, 2001	July 1, 2000	Estimates Base	Census	
United States	304,059,724	301,290,332	298,362,973	295,560,549	292,892,127	290,210,914	287,726,647	285,039,803	282,171,936	281,424,602	281,421,906	
Northeast	54,924,779	54,761,693	54,627,987	54,531,266	54,459,795	54,319,451	54,134,361	53,910,648	53,666,821	53,594,797	53,594,378	
Midwest	66,561,448	66,312,562	66,047,830	65,785,263	65,566,340	65,299,248	65,058,431	64,805,832	64,492,694	64,395,207	64,392,776	
South	111,718,549	110,335,133	108,716,622	107,244,182	105,745,280	104,339,107	103,125,430	101,838,852	100,558,339	100,235,848	100,236,820	
West	70,854,948	69,880,944	68,970,534	67,999,838	67,120,712	66,253,108	65,408,425	64,484,471	63,454,822	63,198,750	63,197,932	
Alabama	4,661,900	4,626,595	4,587,564	4,537,299	4,506,574	4,486,598	4,469,906	4,462,832	4,451,687	4,447,355	4,447,100	
Alaska	686,293	681,111	676,301	668,625	660,975	650,426	642,391	633,160	627,428	626,931	626,932	
Arizona	6,500,180	6,353,421	6,178,251	5,961,239	5,750,475	5,585,512	5,449,195	5,303,632	5,166,810	5,130,607	5,130,632	
Arkansas	2,855,390	2,830,557	2,804,199	2,768,918	2,740,191	2,717,909	2,689,601	2,689,601	2,678,217	2,673,386	2,673,400	
California	36,756,666	36,377,534	36,121,296	35,885,415	35,629,666	35,307,398	34,916,495	34,507,030	33,998,767	33,871,650	33,871,648	
Colorado	4,939,456	4,842,770	4,751,474	4,662,734	4,600,050	4,548,339	4,503,156	4,431,918	4,327,788	4,302,015	4,301,261	
Connecticut	3,501,252	3,489,868	3,487,896	3,478,714	3,475,351	3,467,932	3,448,261	3,428,208	3,411,714	3,405,604	3,405,565	
Delaware	873,092	861,953	850,366	838,519	825,682	814,262	803,774	794,498	786,404	783,595	783,600	
District of Columbia	591,833	587,868	585,419	582,049	579,521	577,371	579,112	577,678	571,723	572,053	572,059	
Florida	18,328,340	18,199,526	18,019,093	17,702,476	17,313,811	16,937,337	16,652,679	16,340,734	16,047,246	15,982,813	15,982,378	
Georgia	9,685,744	9,523,297	9,318,715	9,093,958	8,910,741	8,732,924	8,583,674	8,418,592	8,230,053	8,186,812	8,186,453	
Hawaii	1,288,198	1,277,356	1,275,264	1,264,468	1,251,532	1,238,333	1,227,391	1,217,955	1,211,479	1,211,538	1,211,537	
Idaho	1,523,816	1,496,145	1,461,183	1,424,127	1,390,329	1,363,010	1,341,408	1,320,732	1,299,474	1,293,953	1,293,953	
Illinois	12,901,563	12,825,809	12,759,673	12,704,063	12,665,718	12,611,047	12,565,228	12,510,596	12,437,888	12,419,660	12,419,293	
Indiana	6,376,792	6,335,862	6,294,124	6,248,569	6,210,801	6,178,828	6,146,974	6,123,942	6,091,322	6,080,522	6,080,485	
Iowa	3,002,555	2,983,360	2,967,270	2,951,775	2,942,739	2,933,407	2,929,395	2,929,294	2,928,046	2,926,381	2,926,324	
Kansas	2,802,134	2,777,382	2,756,267	2,742,204	2,731,069	2,722,070	2,712,561	2,701,346	2,692,681	2,688,816	2,688,418	
Kentucky	4,269,245	4,236,308	4,199,440	4,165,958	4,135,567	4,110,922	4,086,754	4,066,442	4,048,831	4,042,284	4,041,769	
Louisiana	4,410,796	4,373,310	4,243,634	4,495,627	4,487,830	4,473,558	4,465,215	4,460,395	4,468,879	4,468,968	4,468,976	
Maine	1,316,456	1,315,398	1,313,355	1,311,044	1,307,904	1,302,729	1,293,667	1,284,663	1,277,179	1,274,922	1,274,923	
Maryland	5,633,597	5,618,899	5,602,258	5,575,552	5,538,989	5,495,009	5,439,327	5,375,659	5,310,451	5,296,516	5,296,486	
Massachusetts	6,497,967	6,467,915	6,443,424	6,434,343	6,434,144	6,441,440	6,433,043	6,407,269	6,362,583	6,349,113	6,349,097	
Michigan	10,003,422	10,049,790	10,083,878	10,093,266	10,090,280	10,065,881	10,037,303	10,004,341	9,955,146	9,938,442	9,938,444	
Minnesota	5,220,393	5,182,360	5,143,134	5,104,890	5,078,014	5,046,708	5,016,643	4,982,339	4,933,787	4,919,492	4,919,479	
Mississippi	2,938,618	2,921,030	2,896,713	2,898,209	2,884,596	2,866,711	2,858,013	2,853,061	2,848,293	2,844,666	2,844,658	
Missouri	5,911,605	5,878,399	5,832,977	5,785,130	5,742,650	5,704,639	5,675,641	5,641,994	5,605,868	5,596,678	5,595,211	
Montana	967,440	956,624	945,428	934,888	925,969	916,754	909,859	905,854	903,283	902,190	902,195	
Nebraska	1,783,432	1,769,473	1,759,779	1,751,069	1,741,450	1,732,873	1,724,236	1,717,705	1,713,194	1,711,266	1,711,263	
Nevada	2,600,167	2,554,344	2,484,196	2,401,671	2,323,875	2,233,830	2,164,518	2,093,973	2,018,244	1,998,257	1,998,257	
New Hampshire	1,315,809	1,312,256	1,308,824	1,300,530	1,292,064	1,281,260	1,270,701	1,256,625	1,240,361	1,235,785	1,235,786	
New Jersey	8,682,661	8,653,126	8,640,218	8,634,657	8,620,770	8,589,562	8,547,410	8,490,942	8,430,913	8,414,360	8,414,350	
New Mexico	1,984,356	1,964,402	1,937,916	1,912,884	1,889,266	1,867,909	1,848,986	1,828,330	1,820,704	1,819,041	1,819,046	
New York	19,490,297	19,429,316	19,367,028	19,336,766	19,301,113	19,230,877	19,161,573	19,088,220	18,998,429	18,976,816	18,976,457	
North Carolina	9,222,414	9,041,594	8,845,343	8,661,061	8,523,199	8,409,660	8,311,263	8,199,913	8,078,824	8,046,500	8,049,313	
North Dakota	641,481	637,904	636,453	635,222	636,196	632,689	633,521	636,211	641,183	642,195	642,200	
Ohio	11,485,910	11,477,641	11,458,390	11,450,954	11,445,095	11,430,306	11,410,582	11,391,298	11,363,719	11,353,160	11,353,140	
Oklahoma	3,642,361	3,608,123	3,568,132	3,530,807	3,511,960	3,496,157	3,482,946	3,463,387	3,453,861	3,450,640	3,450,654	
Oregon	3,790,060	3,735,549	3,680,968	3,621,939	3,576,262	3,551,877	3,517,982	3,470,716	3,430,828	3,421,437	3,421,399	
Pennsylvania	12,448,279	12,419,930	12,388,055	12,351,881	12,335,652	12,317,647	12,298,775	12,284,522	12,285,041	12,281,052	12,281,054	
Rhode Island	1,050,788	1,053,136	1,058,991	1,064,439	1,071,095	1,071,302	1,065,937	1,058,065	1,050,725	1,048,319	1,048,319	
South Carolina	4,479,800	4,404,914	4,324,799	4,249,385	4,196,799	4,143,420	4,102,211	4,061,844	4,023,396	4,011,809	4,012,012	
South Dakota	804,194	795,689	787,380	779,315	773,539	766,440	761,709	758,705	755,657	754,837	754,844	
Tennessee	6,214,888	6,149,116	6,068,306	5,983,211	5,906,936	5,849,563	5,799,093	5,753,497	5,703,094	5,689,270	5,689,283	
Texas	24,326,974	23,843,432	23,367,534	22,811,128	22,424,884	22,062,119	21,713,397	21,333,928	20,946,049	20,851,811	20,851,820	
Utah	2,736,424	2,668,925	2,585,155	2,501,262	2,439,852	2,380,462	2,334,462	2,291,066	2,244,210	2,233,204	2,233,169	
Vermont	621,270	620,748	620,196	619,282	618,432	616,702	614,994	612,134	609,876	608,826	608,827	
Virginia	7,769,089	7,698,775	7,628,347	7,546,725	7,454,688	7,363,300	7,276,785	7,188,251	7,104,354	7,079,025	7,078,515	
Washington	6,549,224	6,449,511	6,360,529	6,254,579	6,179,645	6,110,202	6,055,613	5,987,181	5,911,104	5,894,143	5,894,121	
West Virginia	1,814,468	1,809,836	1,806,760	1,804,020	1,803,312	1,802,287	1,799,392	1,798,540	1,806,977	1,808,345	1,808,344	
Wisconsin	5,627,967	5,598,893	5,568,505	5,538,806	5,508,789	5,474,360	5,444,638	5,408,061	5,374,133	5,363,708	5,363,675	
Wyoming	532,668	523,252	512,573	506,007	502,816	499,056	496,969	492,924	493,963	493,782	493,782	
Puerto Rico	3,954,037	3,941,160	3,926,698	3,910,707	3,893,931	3,876,637	3,858,272	3,837,768	3,814,413	3,808,603	3,808,610	

Note: The April 1, 2000 Population Estimates base reflects changes to the Census 2000 population from the Count Question Resolution program and geographic program revisions. See Geographic Terms and Definitions at <http://www.census.gov/popest/geograp hic/> for a list of the states that are included in each region.

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Table 1: Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2000 to July 1, 2008 (NST-EST2008-01)
 Source: Population Division, U.S. Census Bureau
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