THE HOWARD H. BAKER JR CENTER for PUBLIC POLICY

Project Report 2:14

A Profile of the Energy Sector in Tennessee

A Report to the
Tennessee State General Assembly

By
Matthew N. Murray, Director
Howard H. Baker Jr. Center for Public Policy

Charles Sims, Baker Faculty Fellow
Bruce Tonn, Baker Fellow
Jean Peretz, Baker Fellow
Howard H. Baker Jr. Center for Public Policy

Jeff Wallace, Ryan Hansen, and **Lew Alvarado**
Sparks Bureau of Business and Economic Research
University of Memphis

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THE UNIVERSITY of TENNESSEE
KNOXVILLE

THE HOWARD H. BAKER JR CENTER for PUBLIC POLICY

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Howard H. Baker Jr. Center for Public Policy
1640 Cumberland Avenue
Knoxville, TN 37996-3340

bakercenter.utk.edu
865.974.0931
bakercenter@utk.edu

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EXECUTIVE SUMMARY

In the 108th session of the Tennessee General Assembly, legislation was passed directing the Howard H. Baker Jr. Center for Public Policy at the University of Tennessee and the Sparks Bureau of Business and Economic Research at the University of Memphis to "…perform a study on the economic feasibility of creating and utilizing a statewide comprehensive energy plan. The study shall examine the state's current and future energy supply and demand needs, existing energy policies, and emerging energy challenges and opportunities." This report is our collective effort to fulfill this legislative mandate.

In addressing our charge from the General Assembly, we have placed heavy emphasis on providing background data and information to inform the public and policymakers. In other words, we have sought to provide a resource that will be of lasting value to those who are interested in state energy issues. Our goal is to provide stakeholders with a better understanding of Tennessee's energy sector and how it fits within the context of regional, national and global markets and policy influences. It is essential that public policy be built on a common foundation of information and knowledge to ensure stakeholder support and policy efficacy.

Our focus on the *energy sector* is intended to provide a comprehensive framework to guide the analysis. The energy sector as defined here is far reaching to account for the various ways energy impacts the state economy and the welfare of its residents. It includes the state's endowment of renewable and nonrenewable resources that can be used directly or indirectly to supply energy and potentially support job creation in Tennessee; the systems that generate, transmit and distribute energy, especially electrical energy; broad consumer groups (residential, commercial, industrial and transportation end users); energy prices; and environmental and health consequences associated with energy development and use. Each of these subject areas is addressed in some detail in the report and extensive references are provided to support deeper inquiry.

Our definition of the energy sector is broad enough to include final consumer products that may demonstrate high levels of energy efficiency and the business equipment and machinery that might go into resource extraction and energy production. While these product markets are only mentioned in passing in the report, they are potential targets for a future economic development plan strategically focused to help position the state as a leader in energy markets broadly defined.

Development of a statewide energy plan must account for the many external influences that may affect energy sector outcomes in Tennessee, including energy supplies and prices. Many energy *markets*, including the market for petroleum, are global in nature, leaving little room for state policy. External *policy* influences can also affect Tennessee in significant ways. For example, regulations promulgated by the Environmental Protection Agency (EPA) will continue to affect the portfolio of inputs used by the Tennessee Valley Authority (TVA) to generate electricity. Even policy in faraway places may affect markets in Tennessee, such as China's recently implemented restrictions on imports of coal with high ash and sulfur content that could affect coal exports from the state. Together these influences constitute the external environment that markets in Tennessee must confront and within which state policy must be developed.

Policy development must also be sensitive to other forces that may help shape the evolution of the state's energy sector. This forward-looking view is critical if the state chooses to make long-term and potentially costly investments in the future of the energy sector. As we have shown, the energy plan cannot be developed in isolation as it is just one part of a bigger system. For example, the emergence of new technologies for energy storage could fundamentally transform the solar sector and also lead to the mass adoption of electric automobiles. This would have dramatic effects on TVA and the state's large automobile assembly sector; and state government would have to identify alternatives to the traditional gasoline tax to fund our transportation infrastructure.

Our analysis of the state's energy sector yields a number of important findings. Here we highlight some of the most significant:

- While TVA is the primary producer of electricity for Tennessee businesses and households, it is not subject to state regulatory oversight. TVA nonetheless works cooperatively with state government and the general public, including work related to its Integrated Resource Plan. TVA's independence sharply constrains the state's role in energy policy compared to other states that are not under the TVA umbrella. A plan developed in Tennessee may provide spillover benefits for other states in the TVA service delivery area that are interested in state energy policy.
- Waste ("rejected") energy in Tennessee exceeds the amount of energy actually consumed by Tennesseans. The state's aging residential housing stock and household appliances are

relatively inefficient and per capita income lags the nation. This means that utility costs can be burdensome for many households in the state. There appears to be significant room for more aggressive efforts to promote energy efficiency and conservation. Reduced energy use will benefit the environment and free up household purchasing power for use in other areas of the state's economy.

- Petroleum is the largest energy source consumed in Tennessee and virtually all petroleum is imported into the state. The transportation sector is the predominant consumer of petroleum and is characterized by the highest level of wasted energy. The transportation sector is also the source of environmental pollutants that can harm the environment and public health.
- Coal is the second-most important energy source in Tennessee and is used primarily for centralized power generation by TVA. The state has significant coal reserves but for reasons of cost and quality, coal production has been in decline in Tennessee. Environmental concerns and low natural gas prices will likely mean a continued downward trend for coal production in Tennessee.
- Aside from coal, the state has limited fossil fuel reserves. There may be opportunities for fracking, but natural gas prices must rise before further exploration can take place. Solar power and biomass appear to offer the potential for further exploitation which could lead to job creation in Tennessee, especially in rural communities. This would be an important means of increasing the use of in-state energy sources while at the same time promoting economic development.
- Environmental regulations have led to a marked reduction in some emissions, notably lead and ground level ozone. Particulate matter (PM2.5) remains an ongoing concern. The state's efforts to promote economic development must be balanced against the need for environmental stewardship to protect and improve public health and preserve the state's natural assets, which are all required for a prosperous Tennessee.

It is our conclusion that the state could reap significant benefits from development and implementation of statewide comprehensive energy plan. If such a plan is pursued, it will be important to create an inclusive process that solicits input from a wide range of stakeholder groups. The plan should have well-defined goals and objectives as was discussed in Chapter 1. And the plan should have a champion or group of champions to ensure effective implementation as recommended in Chapter 7. Only then can the state move toward energy resiliency and enhanced economic prosperity.

CHAPTER 1. INTRODUCTION

By Matthew N. Murray, PhD, Howard H. Baker Jr. Center for Public Policy

Our Charge

In the 108th session of the Tennessee General Assembly, legislation was passed directing the Howard H. Baker Jr. Center for Public Policy at the University of Tennessee and the Sparks Bureau of Business and Economic Research at the University of Memphis *to "…perform a study on the economic feasibility of creating and utilizing a statewide comprehensive energy plan. The study shall examine the state's current and future energy supply and demand needs, existing energy policies, and emerging energy challenges and opportunities."* The report presented here is our collective effort to fulfill this legislative mandate. We have interpreted our charge broadly and have sought to provide data and information that can inform the public and lays a foundation for policy development.

Focus and Structure of the Report

Developing a comprehensive statewide energy plan is certainly a feasible undertaking. A thoughtful and well-designed plan could help support state economic development goals while improving environmental outcomes for residents. The more aggressive and comprehensive the statewide energy plan is intended to be, the more important it will be to have a deep understanding of the state's energy sector. Developing a plan is not an easy undertaking—it takes time, detailed information and the cooperative engagement of stakeholders and policymakers. An essential foundation for policy development is a good understanding of the state's energy sector, from energy resource extraction to energy distribution and final use.

A primary goal of this report is to provide such a data-driven foundation. From a policy perspective it also necessary to identify various state and local, governmental and nongovernmental, and internal and external bodies that can exercise an influence over energy sector outcomes. Tennessee's position in this respect is especially unique given the dominant role played by the Tennessee Valley Authority (TVA) in generating, transmitting and distributing electricity for the lion's share of consumers in the state.

This report focuses broadly and comprehensively on Tennessee's *energy sector*. This includes the extraction and cultivation of primary energy sources, from coal to biomass. It includes renewable resources like hydro power and nonrenewable resources like natural gas. This renewable and nonrenewable resource base represents the state's endowment of energy-producing assets. The distribution and transportation of secondary energy sources (electricity) and primary energy sources (e.g. gasoline) is also addressed. These energy flows reflect market supply and demand as well as a range of public policies and regulatory influences. Broad classes of end-use energy consumers are included, bundled under the conventional headings of residential consumers (i.e. households), industrial and commercial users, and the transportation sector. These groups represent the primary stakeholders in terms of energy use. Energy costs and prices and environmental and health impacts of energy production and consumption are additional elements of the discussion that are important to consumers and producers alike. A healthy dose of speculation is included in the narrative regarding the future of the energy sector. Future energy sector outcomes can be highly uncertain if not volatile.

A natural question to ask is: ***Why does Tennessee need an energy plan?*** The simple answer is that **a plan allows policy to shape the evolution and development of a state's energy sector in order to meet the needs of primary stakeholders--residents and businesses.** Residents want low-cost, stable energy prices while preserving human health and the natural beauty of the state; businesses require low costs and stable energy supplies in order to maintain their competitiveness. A formal plan facilitates policy coordination across state agencies within state government, and potentially across local government as well. Market forces, along with federal government regulation and other actions, will have the largest impacts on a state's energy sector. But the state can nonetheless tilt the direction of the energy sector to meet its own needs and interests including economic development objectives like job creation and tax base expansion. Importantly**, a formal plan can provide greater policy certainty for market participants who may be interested in making energy sector investments in the state.** This is especially important for Tennessee since most states already have some form of energy plan in place. [1]

Rapid Changes Are Taking Place in the Energy Sector

The dramatic changes now taking place in the energy sector suggest that this is an opportune time for policy action. To provide motivation, consider some of the changes that are underway.

[1] See http://www.naseo.org/Data/Sites/1/naseo_39_state_final_7-19-13.pdf and http://www.naseo.org/Data/Sites/1/documents/publications/NASEO-State-Energy-Planning-Guidelines.pdf. Accessed October 7, 2014. New Hampshire has recently released a new plan, see http://www.nh.gov/oep/energy/programs/SB191.htm.

- **The recent growth of hydraulic fracturing**—or fracking—has revolutionized the natural gas industry. The additional supply has driven down prices and encouraged electricity generators to shift away from coal to natural gas. The Environmental Protection Agency's proposed Clean Power Plan would further restrict the use of coal by the nation's power plants and contribute to the ongoing decline in coal demand and extraction.[2] The projected decline in coal extraction means the loss of jobs in some regions like West Virginia, while fracking means the creation of jobs elsewhere, including Pennsylvania and North Dakota. This has consequences for economic development, the environment and the finances of state and local governments. How this transition plays out in Tennessee depends on the extent of private and public investments in energy infrastructure and exploration of shale gas reserves in the state, especially the Chattanooga Shale play (i.e. field).
- **Growth in the demand for gasoline has slowed** and strong fuel economy gains are expected for the nation's stock of light vehicles--new Corporate Average Fuel Economy (CAFE) standards will lead to dramatic efficiency gains by 2025. Changing residential location and driving patterns, along with improved fuel efficiency means downward pressure on revenues derived from the state's gasoline tax which has not seen a rate increase since 1991. This will affect shared gasoline tax collections with local governments in Tennessee and place financial pressure on the state's transportation infrastructure funding capacity.
- **New technologies for biomass conversion, power generation from hydrogen, and storage batteries** have the potential to reshape the structure of today's internal combustion engine which propels our fleet of automobiles. Tennessee is a top ten producer of light vehicles and is home to major automobile manufacturers, including Nissan, General Motors and Volkswagen. They and hundreds of suppliers have invested billions of dollars in production capacity in the state. A revolution in vehicle propulsion could have significant effects on the state's large and growing transportation equipment sector. Would the state's major automobile assemblers respond to fundamental breakthroughs and choose to reinvest in Tennessee or move production capacity elsewhere? Do these emerging technologies offer economic development opportunities for the state?
- **Distributed generation**, i.e. the generation of power from smaller technologies as opposed to large centralized power facilities is becoming more and more popular. For households,

[2] For background, see Mary R. English, *The Clean Power Plan: Regulating Carbon Dioxide Emissions from Existing Power Plants*, Policy Brief 2.14, Baker Center for Public Policy, August 2004. http://bakercenter.utk.edu/wp-content/uploads/sites/4/2013/05/709860-English-Policy-Brief-3.pdf. Accessed October 14, 2014.

the most common source of distributed generation is rooftop solar, i.e. photovoltaic (PV) cells. Businesses have adopted PV units as well, along with other sources of onsite power generation and cogeneration. Technological developments are making these alternatives more and more cost effective. Some existing policies, like local zoning restrictions, may limit the deployment of rooftop solar units; tax or financial incentives, on the other hand, could encourage adoption. Distributed generation has implications for the nation's electric grid. Moreover, if adoption becomes significant and widespread this could place some existing central generating capacity at risk of obsolescence. This is coupled with an aging fleet of generating units in the state that are nearing the end of their planned lifespan. The timing of these two forces will have long-term implications for electricity rates in the state.

- Compared to other states, **Tennessee households confront relatively high annual energy costs** because of the quality of the housing stock and wide temperature fluctuations over the course of the year. Tennesseans also have relatively low income compared to the nation. Mitigating these two forces is relatively low rates for electricity use in the state. Efforts to promote energy efficiency and conservation could free up purchasing power for discretionary household purchases and improve quality of life for Tennesseans. Lower levels of electricity consumption could improve sales tax collections if consumer spending shifted to sales taxable purchases. Reduced energy use may lead to environmental improvements.
- The state economy has historically relied heavily on manufacturing for job creation and tax base expansion**. Targeted economic development programs that focus on the state's energy sector and its comparative advantages** may allow the state to create a new niche and industrial cluster. The state has a central location, an attractive tax and business climate, and a skilled manufacturing workforce. Other assets include initiatives in biomass and solar power, along with the Department of Energy's Oak Ridge National Laboratory and the University of Tennessee. Picking winners is difficult, but a strategy could be developed to harness the state's resources and raise the attractiveness of Tennessee as a place to do business in the energy sector.
- **Major public and private sector investments in alternative energy sources are taking place across the country.** Tennessee is not well endowed with some resources, like petroleum or geothermal capacity. But it does appear to have some potential to further promote solar and biomass for electricity generation and motor fuel. This could help

promote private capital investment and job creation in power generation but also in the production of the underlying technologies that generate power.

The Structure of a State Energy Plan

A state energy plan must be driven by well-defined goals and objectives and should include a formal and inclusive process for stakeholder engagement. The specificity of goals and objectives provides a foundation for policy development and evaluation. Stakeholder engagement ensures all voices are heard and ultimately creates ownership of a plan, its recommendations and resulting policy. According to the National Association of State Energy Officers (NASEO), most states either have an active energy plan in place or are in the processing of amending their current plan. NASEO has developed reports that can be of assistance to Tennessee as it proceeds with the development of a statewide plan. These documents provide practical guidance on the structure and key elements of existing plans, as well guidance on the planning process itself. The General Assembly and other stakeholders are encouraged to review these plans for insight and guidance on best practices.

A review of state energy plans reveals substantial variation in their scope and intent. In some instances the stated goals and objectives can be in conflict with one another and reflect tradeoffs that must be addressed in policy development. For example, the goal of promoting economic development must be balanced against the goal of environmental stewardship. In some instances, as with renewable portfolio standards which are mentioned immediately below, there is a disconnect between goals and means of attaining a goal—renewable portfolio standards as a mechanism to achieve other goals like a smaller environmental footprint.

There are many examples of possible policy goals and here are just a few to consider:

- **Sustainability** – balance the promotion of resource extraction, energy use and economic development against the need for environmental protection and stewardship.
- **Promote economic development and competiveness** – target business recruitment and retention of firms that can build on a state's energy sector assets and pursue policies that ensure reliable supplies and low-energy costs for instate businesses.
- **Renewable portfolio standards** – promote the use of a diversified set of energy resources, including renewable energy sources, to protect the environment, create economic development gains and reduce reliance on energy imports.

- **Energy efficiency** – reduce energy costs for residents, the public sector and the transportation, commercial and industrial sectors, to free up household purchasing power, maintain low taxes, improve business competitiveness and reduce energy consumption.
- **System resiliency and security** – ensure that the energy generation and delivery system is robust in the face of adverse weather and security threats.
- **Price stability and affordability** – ensure that prices are not overly volatile and that energy is affordable to end users.

The Road Ahead

The remainder of this report is intended to provide a conceptual and data-driven foundation for discussion and debate of state energy policy and a statewide energy plan. **Chapter 2 looks outside the borders of Tennessee and places the state's energy sector in a global, national and regional context. Global -** because most energy markets (including petroleum) are global in nature and these markets heavily influence prices and supplies of many energy sources for Tennessee. **National -** because there are also national markets (e.g. solar and wind generation) and national policy bodies (including EPA and the Federal Energy Regulatory Commission) that affect market outcomes in Tennessee. **Regional -** because most electricity generation in Tennessee occurs through TVA. These external influences place significant limits on state policymakers and their ability to affect energy sector outcomes, including energy supplies and prices. The chapter also discusses some of the fundamental changes taking place that will affect the global and state energy sectors, including the rapid pace of technology development, shifts in the demographic mix of the population and emerging threats to energy infrastructure. It is critical that this external environment be thoughtfully considered when state policy is developed because it will help shape the state's role in domestic and world energy markets.

Several subsequent chapters dissect major components of the state's energy sector. **Chapter 3 explores energy flows in Tennessee and the final end-use consumption** of energy by broad consumer group. This chapter provides a 60,000 foot view of the state's energy sector. It helps illustrate the state's reliance on external sources of energy and also identifies the dramatic scope of wasted (i.e. "rejected") energy. Petroleum is the largest energy source in the state, followed by coal.

Because of its importance to both households and businesses, as well as the unique role played by TVA, **Chapter 4 is dedicated to electricity generation**. Electricity is a form of "secondary energy" that is produced using a variety of primary energy sources such as oil, coal, natural gas, nuclear and biomass. While TVA dominates the state in terms of electricity production, there are a number of independent power producers and both households and businesses are increasingly supplying their own electricity. The rapid pace of technological change that is discussed in Chapter 2 would suggest that these nonconventional sources of electricity generation will grow in the years ahead.

Chapter 5 focuses on the state's natural resource base and the production of primary energy in the state. This chapter is especially important in identifying resources that might be further utilized to produce energy while also yielding economic benefits for the state. Tennessee is not well endowed with fossil fuels and produces a very small volume of petroleum. Shale gas may offer greater promise if and when prices rise from currently low levels. Wind offers limited potential in Tennessee. While the state has significant coal reserves, demand for Tennessee coal has been declining because of low-priced natural gas and environmental concerns. Biomass and solar appear to offer greater potential for further exploitation.

Chapter 6 highlights the environmental and health implications of energy consumption and production in the state. Environmental regulations have been instrumental in reducing emissions associated with adverse health outcomes, including ozone and lead. Particulate matter (PM2.5), on the other hand, continues to pose significant health risks to Tennesseans.

The **final chapter ties things together with an eye on policymaking.** Specifically addressed are the focus areas embedded in the legislative mandate to the Baker Center and the Sparks Bureau. As this report was developed, the decision was made to place considerable emphasis on foundational information that could inform the public and policymakers thus facilitating the policy-development process. The conclusion is our collective effort to bring the lens back more specifically to state policy and a state energy plan. While the report directly and indirectly speaks to policymaking bodies, it is certainly far from comprehensive. Accordingly, the Appendix exposes readers to various public and private sector bodies that have the capacity to affect electricity outcomes in the state, all the way from the federal government down to industry associations that represent the state's resource extraction sector. This helps illustrate the complex environment within which state policy must be developed and implemented.

CHAPTER 2. GLOBAL ENERGY SYSTEMS FROM A TENNESSEE VIEWPOINT

By Bruce Tonn, PhD, Howard H. Baker Jr. Center for Public Policy

Key Points

The purpose of this chapter is to situate Tennessee's energy sector within national and international energy markets and systems. To accomplish this task, the chapter assesses the state's relationships with the major fossil fuel markets, nuclear power, and the electricity generation sector and identifies several trends that could significantly change the structure of Tennessee's energy system in the future. To summarize, **the chapter makes these key points**:

- The state is dependent upon international and national markets for fossil fuels. The state has little or no ability to influence the price or supply of these fuels.
- The state relies almost wholly upon TVA to produce and distribute electricity to its residents and businesses. This is a unique situation compared to the rest of the states in the nation.
- The state does have the potential to influence the efficient use of energy across all sectors.
- The state does have the potential to shape economic development strategies around energy production (e.g., biofuels) and technology (e.g., energy storage) sectors.
- Major technological changes in the production and distribution of electricity, storage of energy produced by renewable energy sources, along with advancements in battery technologies for electric vehicles, could significantly change the state's energy system.
- The state's energy system is exposed to various risks, such as those posed by climate change, substantial demographic shifts (e.g., aging population) and acts of international or domestic terrorism, that could significantly alter if not disrupt energy markets and systems.

Introduction

The world energy system is exceedingly complex. It encompasses numerous energy sources, such as oil, natural gas, wind, and solar. Its infrastructure can be continental and even global in scale, as exemplified by national highway systems, electricity grids, oil and natural gas pipelines, and the transport by tankers of crude oil worldwide. Energy end uses span the imagination, from cell phones to aluminum plants, robots to drones, and tractors and refrigerators. Energy and environmental systems interact and overlap in numerous important manners. In fact, many major environmental issues being faced by humanity, from the threat of climate change to the deposition of mercury, cannot be dealt with without addressing energy issues, from resource extraction to final energy use. Further complicating discussions about energy is the fact the worldwide demand for energy is forecasted to increase tremendously in the coming decades (Figure 2.1).

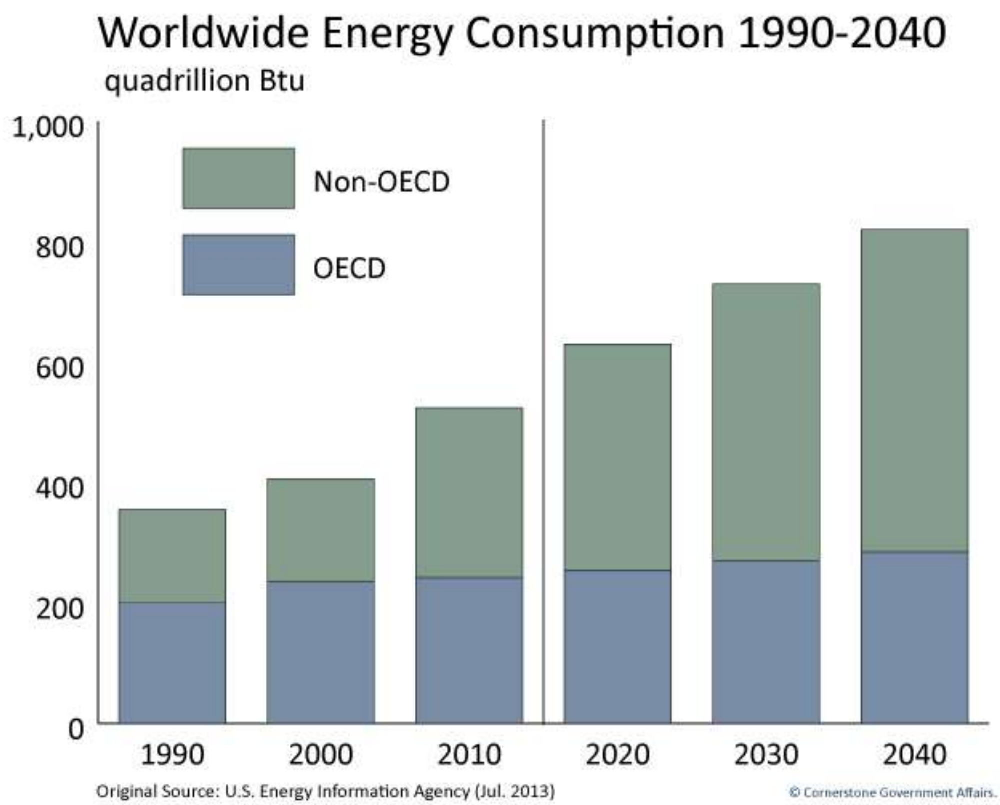

Figure 2.1. Forecasted Worldwide Energy Consumption 1990-2040.
http://www.eia.gov/todayinenergy/detail.cfm?id=12251

From the viewpoint of the state of Tennessee (often simply referred to as the 'state' herein), it is assumed that energy consumers in Tennessee—both households and businesses—prefer inexpensive and clean energy that is reliably available and characterized by stable prices. It is also assumed that the state would like to see economic development gains arise as the state's energy sector is further developed. These basic assumptions represent a foundation that most Tennesseans would accept as the basis for the development of state energy policy and a state energy plan.

This chapter addresses aspects of the world's energy markets that may be controllable from the perspective of the state of Tennessee and those aspects that are beyond the control of the state.

These are important considerations because energy markets in Tennessee are greatly shaped by market and policy influences that lay beyond the state's borders. The point is that there is much the state can do to shape energy markets in Tennessee—i.e. the extraction of natural resources and the generation and distribution of power. At the same time, there are important external forces that limit any state's role in affecting energy market outcomes.

The Big Three: Oil, Natural Gas, Coal

Oil

Oil is an excellent place to start this journey through the world's energy systems. The market for oil is truly international. It is extracted from fields across the globe and shipped across the globe. Typically, crude oil is transported in ocean tankers or pipelines to refineries located at ports on seacoasts. This is one reason why most U.S. refineries are located near major oil fields and on the Gulf coast, major rivers and the Great Lakes. The price for oil is determined by supply and demand conditions (including the influence of Organization of the Petroleum Exporting Countries or OPEC) in international oil markets. Demand for oil is increasing as previously undeveloped countries such as China and India accelerate their economic development. Figure 2.2 suggests that not only has the price for oil been increasing in recent decades, but it has been quite volatile, being highly sensitive to events in the realm of international geopolitics, and a recent ramp-up in oil production in the U.S.

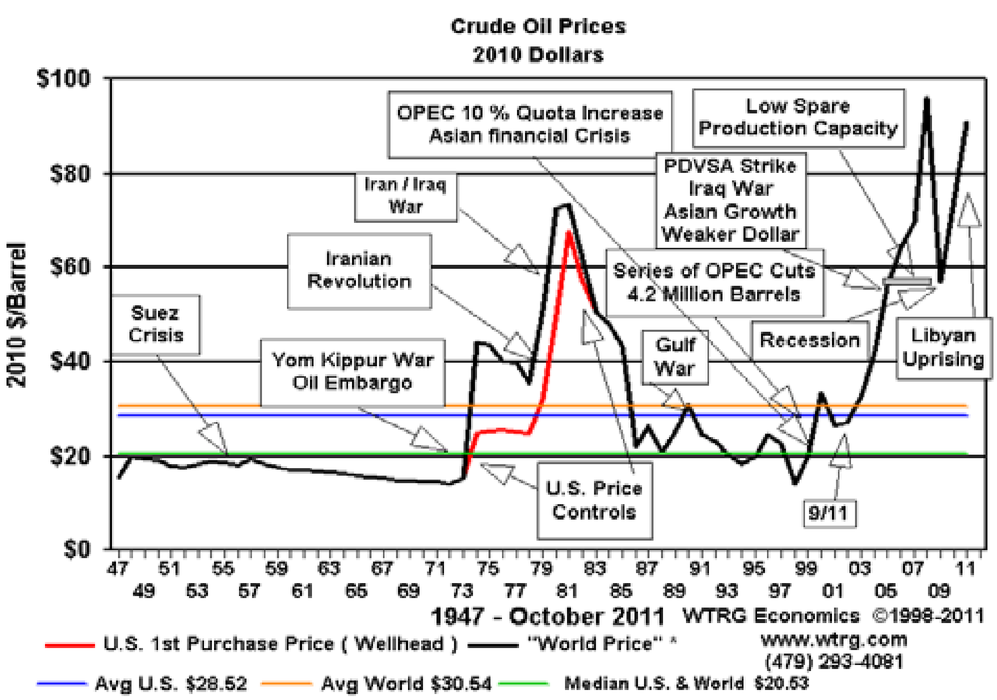

Figure 2.2. U.S. and World Crude Oil Prices Over Time. http://www.wtrg.com/prices.htm

As discussed more in Chapter 3, virtually all of the oil consumed in the state is imported from elsewhere in the U.S. and the world. While it is difficult to track the origin of every gallon of gasoline consumed in the state, in 2013, 32 percent of U.S. petroleum imports came from Canada.[3] The price for this oil is essentially set in the world oil market. If there were major oil producers in Tennessee, they would still want the best price for their oil and that price would be set internationally, though the cost to Tennessee consumers might be fractionally lower due to lower transportation costs. Thus, from the viewpoint of the Tennessee households, businesses and policymakers, oil prices are essentially uncontrollable. Oil supplies are largely uncontrollable as well. Overseas events, from a new war in the Middle East to a replay of the 1970s OPEC oil embargo, could cripple oil supplies to the U.S. and therefore to Tennessee consumers, possibly causing shortages of gasoline for vehicles and diesel for trucks. Even recent extreme weather events in the U.S. Gulf, which crippled oil refining capabilities for a period of time, and problems in the U.S. Midwest had repercussions for gasoline supplies and prices for motorists in Tennessee.

Despite recent advances in oil field extraction technologies and the oil fracking boom in North Dakota and elsewhere, the U.S. will likely be dependent on foreign oil imports into the foreseeable future. And despite the boom of oil production in the U.S., the overall trend in new oil field discoveries has been headed downward for many decades (see Figure 2.3).[4]

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[3] http://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbbl_a.htm

[4] For the most up to date information on supply and consumption, see U.S. Energy Information Administration, *Annual Energy Outlook 2014 with projections to 2040.* April 2014 (DOE/EIA-0383 (2014)). Available at: http://www.eia.gov/forecasts/aeo/. Accessed September 2, 2014.

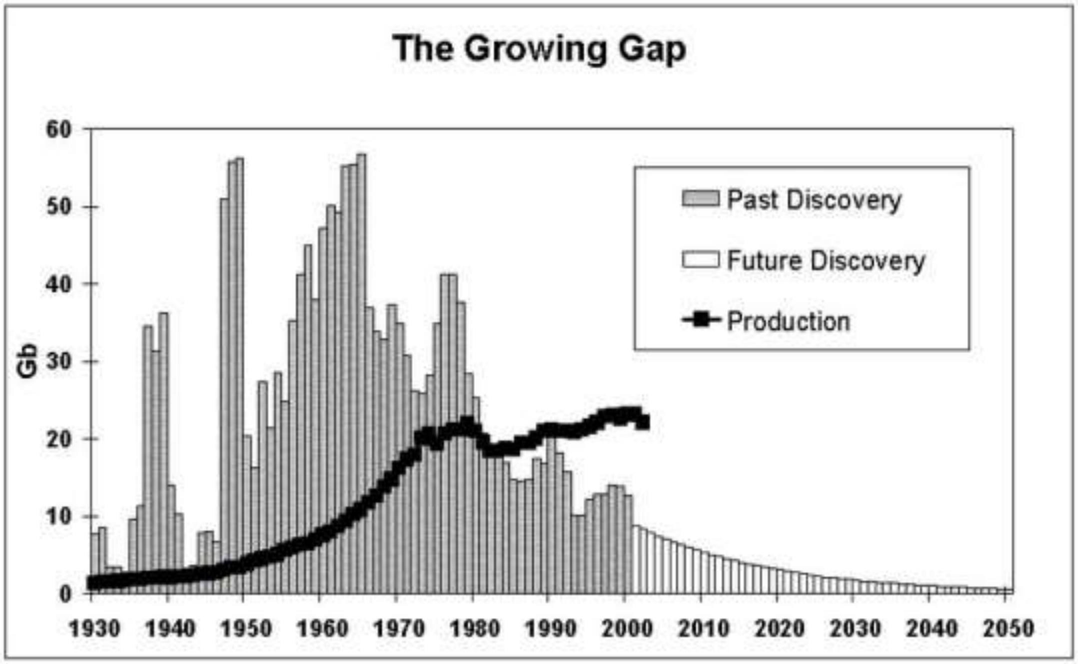

Figure 2.3. Oil Field Discoveries as Measured in Billions of Barrels (GB) versus Oil Production. This is a classic figure that illustrates the concept of peak oil where oil discoveries peaked in the 1960s while oil consumption continues to rise.
http://www.theoildrum.com/uploads/3246/GrowingGap.jpg

Indeed, the lack of new discoveries of major oil fields and the growing world demand for oil has combined to compel many energy analysts to predict that the world's production of oil (i.e., the number of barrels of oil pumped from the ground) will peak in the next couple of decades, if it has not already peaked. The oil fracking boom in the U.S. has certainly delayed the inevitable peak.[5] The U.S. Energy Information Agency (EIA) now estimates that peak U.S. oil production will be hit in 2019.[6] While world peak production may increase and hold at a peak level for several decades, after that and for the balance of human history, oil production will decline. The state of Tennessee will not be alone in its quest to move its energy demand profile away from oil to other sources. This movement will create opportunities for new investments and innovations that could benefit Tennessee from an economic development perspective.

It is often useful to distinguish between energy resources needed to produce electricity versus energy resources needed to fuel the transportation sector (primarily) and on-site generation and consumption by industry and the residential and commercial sectors (secondarily). Oil is primarily

[5] http://www.npr.org/2014/10/17/356713298/predictions-of-peak-oil-production-prove-slippery
[6] http://blogs.wsj.com/moneybeat/2014/12/04/who-to-believe-u-s-natural-gas-may-peak-in-2040-or-2020/

consumed in the U.S. by the transportation sector, though many homes and large multifamily buildings in the Northeast use fuel oil for heat. Oil is used to produce electricity in special circumstances, such as on islands. For example, Puerto Rico imports oil to produce electricity (rather than coal for instance) though its electricity prices are quite high relative to those in the continental U.S.; approximately 27 cents per kWh in Puerto Rico versus 13 cents in the continental U.S in 2013-2014.[7]

Natural Gas

Natural gas is an interesting energy resource because it is used extensively to produce electricity and for on-site combustion. With respect to the former, natural gas historically has been mostly used to fuel electric power plants brought on-line to produce electricity during peak periods of electricity demand or in power plants that can easily increase or decrease power output as needed.[8] This is because natural gas plants can be started and stopped fairly quickly and built in modular units of convenient size. It should be noted that because of both the increase in natural gas production in the U.S. combined with natural gas' lower emissions of greenhouse gases than coal, some electricity producers, such as TVA, are building natural gas plants to also meet baseload (typical) demand while retiring coal plants. With respect to on-site combustion, millions of homes in the U.S. use natural gas for central heat and water heating. Industrial plants use natural gas for on-site generation to power material processing equipment, motors, and for other functions.

From the perspective of the state of Tennessee, the natural gas market is national. This means that most of the natural gas consumed in the U.S. and in Tennessee is extracted from U.S. natural gas fields and then shipped through pipelines throughout the U.S. to distributors and then to consumers (see Figure 2.4).

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[7] http://www.slate.com/articles/business/the_juice/2014/05/puerto_rico_is_burning_oil_to_generate_electricity_it_s_completely_insane.html

[8] In the electricity world, a distinction is made between baseload, load following, and peak period electricity production. Baseload electricity demand represents the average level of electricity demand over the course of a day, week, month and year and is met by large, lower-cost power plants that take time to bring on or off line (e.g., coal plants and nuclear power plants). To keep the grid operational, these large plants operate 24/7. When more power is needed, for example in the late afternoon and early evening when many people come home from work and school and turn on the lights, turn up their air conditioners, start the wash, etc., power plants that can be quickly brought on-line are added to the grid and/or power output is increased plants that can easily ramp up their production (e.g., follow the increase in electricity load), such as combined cycle plants. Typically, these plants are fueled by natural gas. Also, typically, the electricity from these plants costs more to produce. Thus, many utilities work to reduce peak electricity demand to avoid capital and ongoing operational costs.

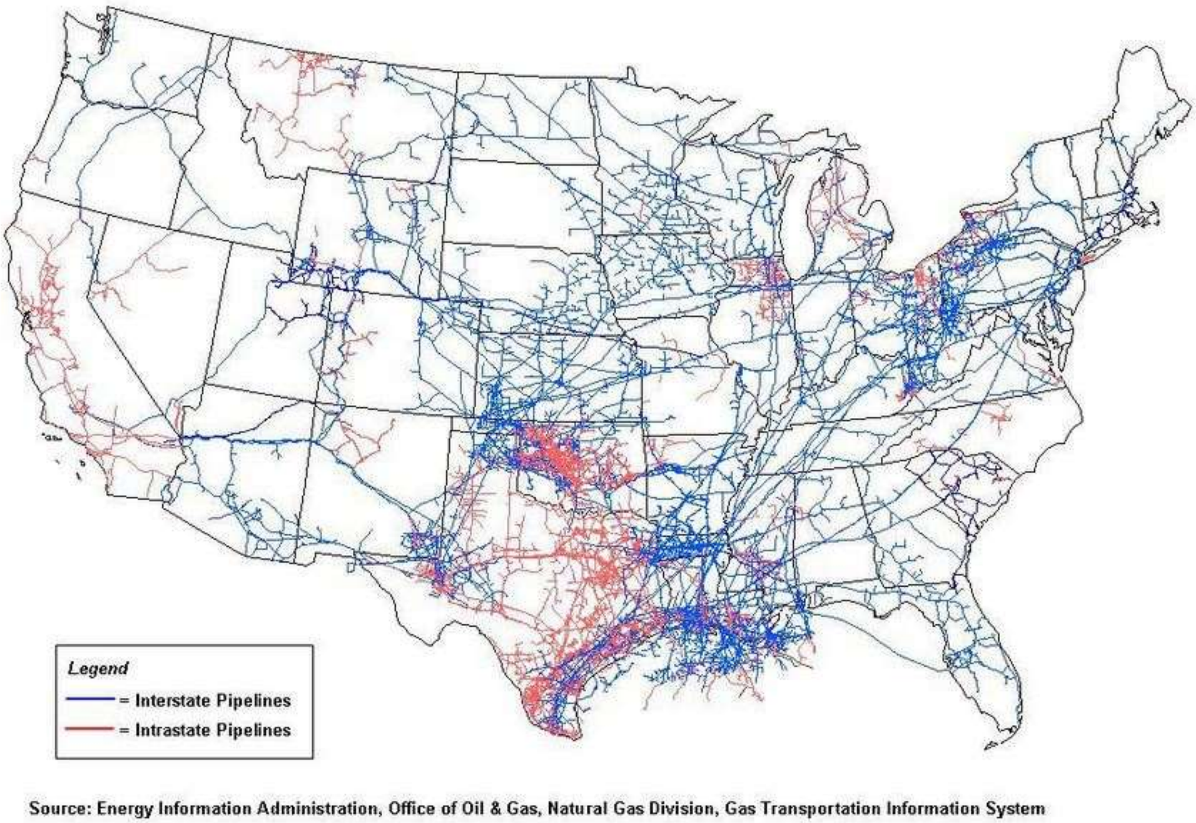

Figure 2.4. The Natural Gas Pipeline Infrastructure of the United States.
http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/ngpipelines_map.html

Some U.S. natural gas is exported and more will likely be exported in the future as supplies from fracking operations grow. To export natural gas, the gas is cooled, liquefied and then loaded into special tanker ships. Recent data indicate that construction of liquefied natural gas terminals has increased in recent years.[9] In Tennessee, natural gas consumers are still price takers, having little to no influence over natural gas prices or supplies. (Regional price variations exist due to differential infrastructure to process and ship gas. Because of Tennessee's geographic location within this national network, in general Tennessee natural gas customers pay somewhat less for this energy resource. [10]) Figure 2.5a suggests that the price of natural gas has been quite volatile historically.

[9] U.S. Department of Energy Office of Fossil Energy. "Long Term Applications Received by DOE/FE to export Domestically Produced LNG from the Lower-48 States (as of November 14, 2014)." Available at: http://energy.gov/fe/downloads/summary-lng-export-applications-lower-48-states. Accessed November 3, 2014.

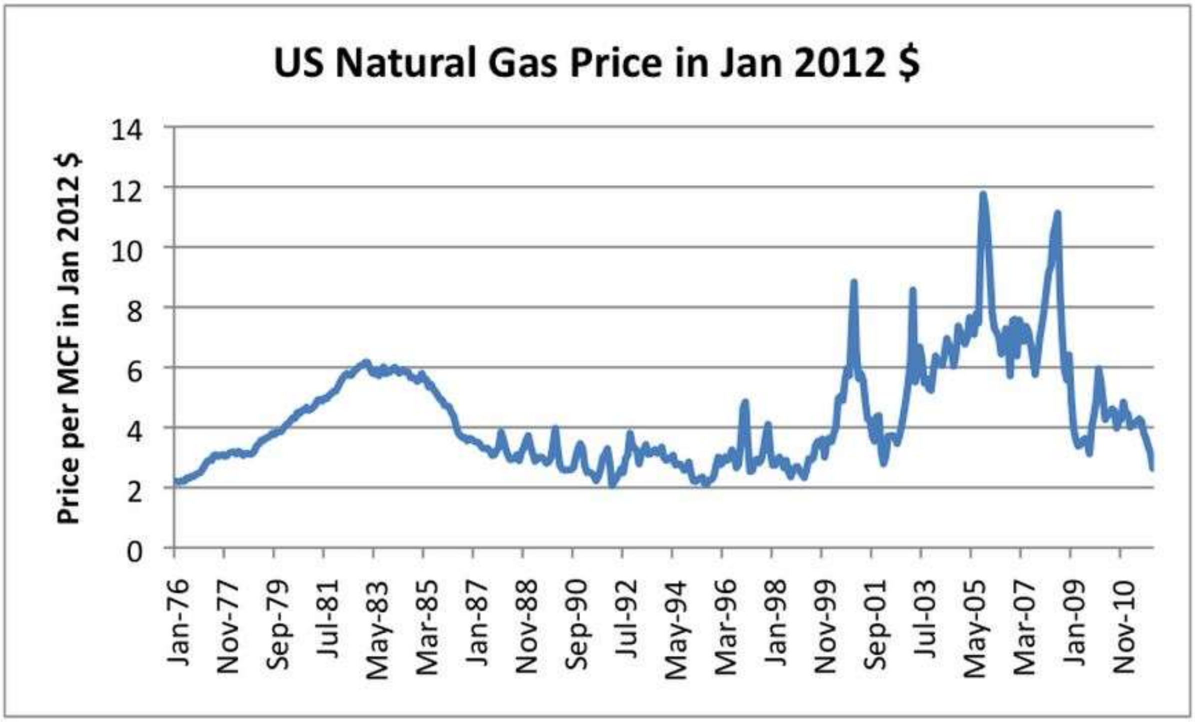

Figure 2.5a. U.S. Natural Gas Prices per Million Cubic Feet (MCF) in January 2012 Dollars. http://orfordecision.wordpress.com/2012/11/14/why-us-natural-gas-prices-are-so-low-are-changes-needed/

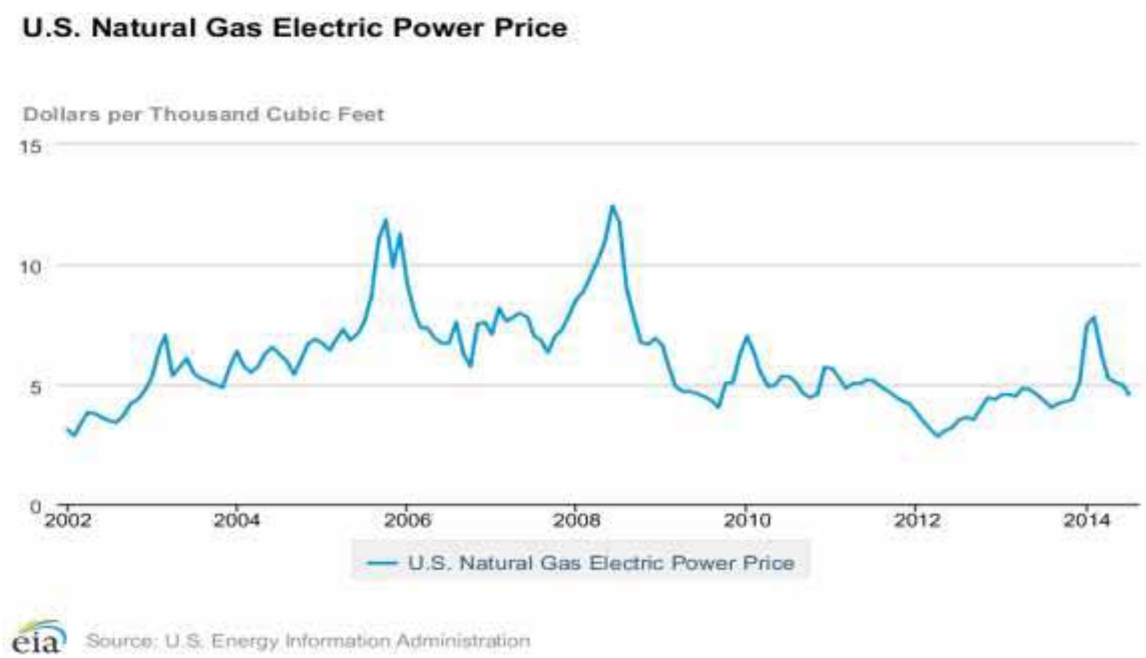

Figure 2.5b. U.S. Natural Gas Prices in Recent Years. http://www.eia.gov/dnav/ng/hist/n3045us3m.htm

The future of natural gas in the U.S. is less fraught with uncertainty than that of oil. A natural gas fracking boom has increased natural gas availability and stabilized and lowered natural gas prices nationwide (See Figure 2.5b). It is logical to assume that a natural gas production peak will be reached at some point because of resource scarcity; analysts see U.S natural gas production hitting its peak by 2040 and possibly even as soon as 2020.[11] Natural gas prices are likely to continue to be volatile because extreme weather events, from hurricanes to heat waves to cold snaps, will still impact the availability and demand for natural gas.

Coal

Coal rounds out the big three sources of energy in the U.S. Coal historically has been almost exclusively used to generate baseload electricity. Though U.S. exports of coal are increasing, the coal market is basically national in scope. Most coal used in the U.S. is now mined in the Western U.S. and transported throughout the U.S. by river and rail. This coal is lower in sulfur context and cheaper to mine than Appalachian coal. Tennessee's provider of electricity, the Tennessee Valley Authority, is a coal price taker and cannot influence the *national* price of coal by any significant degree, though like any buyer it can negotiate multi-year contracts with suppliers to achieve some price stability.

Over time, the price of coal has been the least volatile of the fossil fuels (see Figures 2.6a and 2.6b).

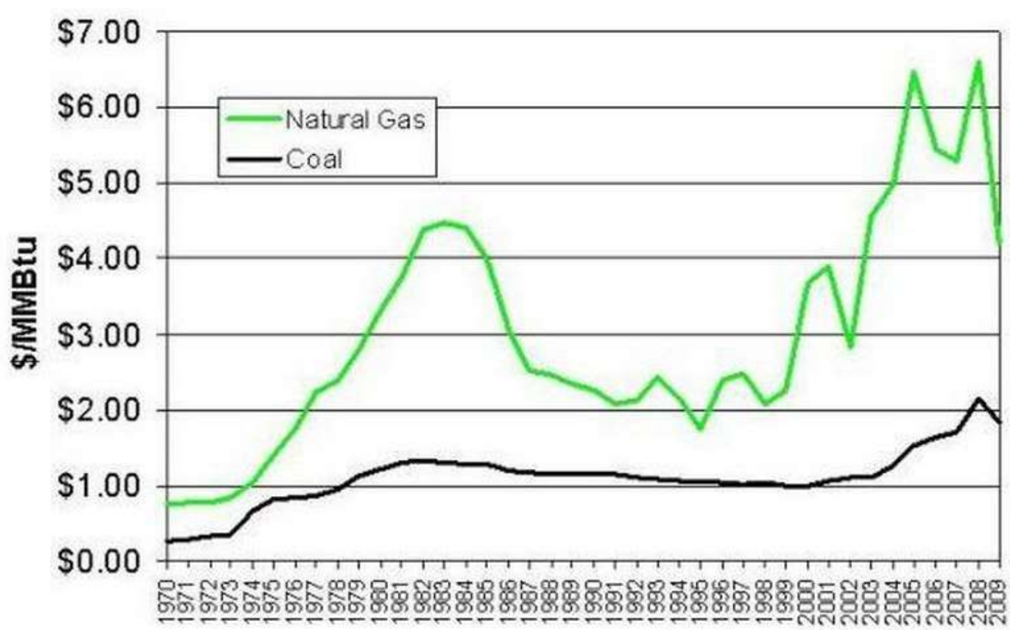

Figure 2.6a. Illustrates U.S. Coal and Natural Gas Prices Over Time in Dollars per Million British Thermal Units (MMBtus). http://grist.org/article/natural-gas-as-a-near-term-co2-mitigation-strategy/

[11] http://blogs.wsj.com/moneybeat/2014/12/04/who-to-believe-u-s-natural-gas-may-peak-in-2040-or-2020/

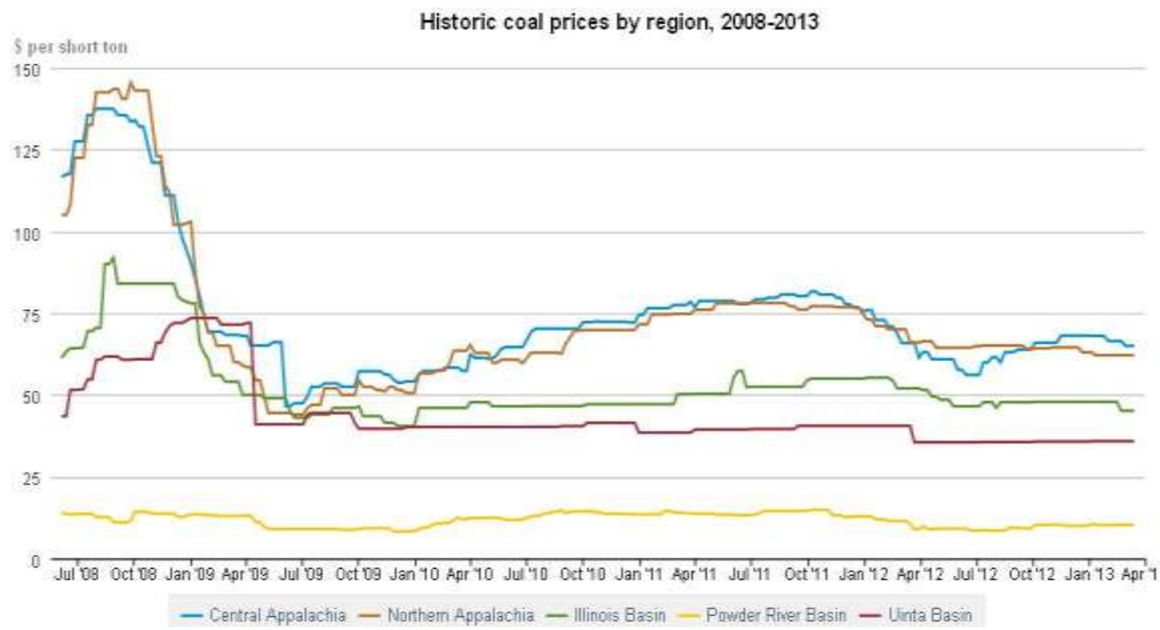

Figure 2.6b. Coal Prices by Region, 2008-2013. U.S. EIA 2013. Coal News and Markets Report. http://www.eia.gov/coal/news_markets/archive/

Its supply to electric power plants has also been very reliable. Its significant downside is the relatively large amount of emissions from its combustion, such as sulfur dioxide, nitrogen oxide, and mercury. It is also associated with environmentally- and socially-controversial mining practices. At present rates of production, peak coal is forecast to be at least a century into the future.[12] However, pressures on utility companies to reduce carbon emissions from their portfolios of power plants may end up drastically reducing coal demand. The EPA's proposed rule regarding carbon emissions from existing power plants (the Clean Power Plan) and concerns from some consumers contribute to this pressure. On the other hand, the implementation of new, cost-effective clean coal technologies could increase coal demand because these technologies require approximately 25-40 percent more coal to supply the same of amount of electricity to end user.[13] A decline in coal extraction and use will have negative economic development consequences for those places that rely on mining as part of their economic base. But, development of clean coal technologies could create jobs and continue to support the coal industry if these technologies

[12] http://en.wikipedia.org/wiki/Peak_coal

[13] *IPCC special report on Carbon Dioxide Capture and Storage*. Prepared by working group III of the Intergovernmental Panel on Climate Change. Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L.A. Meyer (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 442 pp. Available in full at www.ipcc.ch.

allow coal to continue to be cost competitive. Unfortunately, this does not appear to be a viable option in the near-term.[14]

To summarize the discussion up to this point, the state of Tennessee, like most if not all states, has little to no control over the price or supply of its major, fossil-based energy fuel sources— oil, natural gas, and coal.

Tennessee Valley Authority

A fourth major piece of the energy puzzle needs to be introduced now to lay the foundation for the balance of this chapter. This section deals with TVA.

The institutional system that provides electricity to the vast majority of customers in the state of Tennessee is unlike any other system in the U.S. Throughout most of the 20th century, electricity was provided by integrated and regulated utility companies. Integrated utilities owned the power plants, transmission lines, and distribution systems (See Figure 2.7).

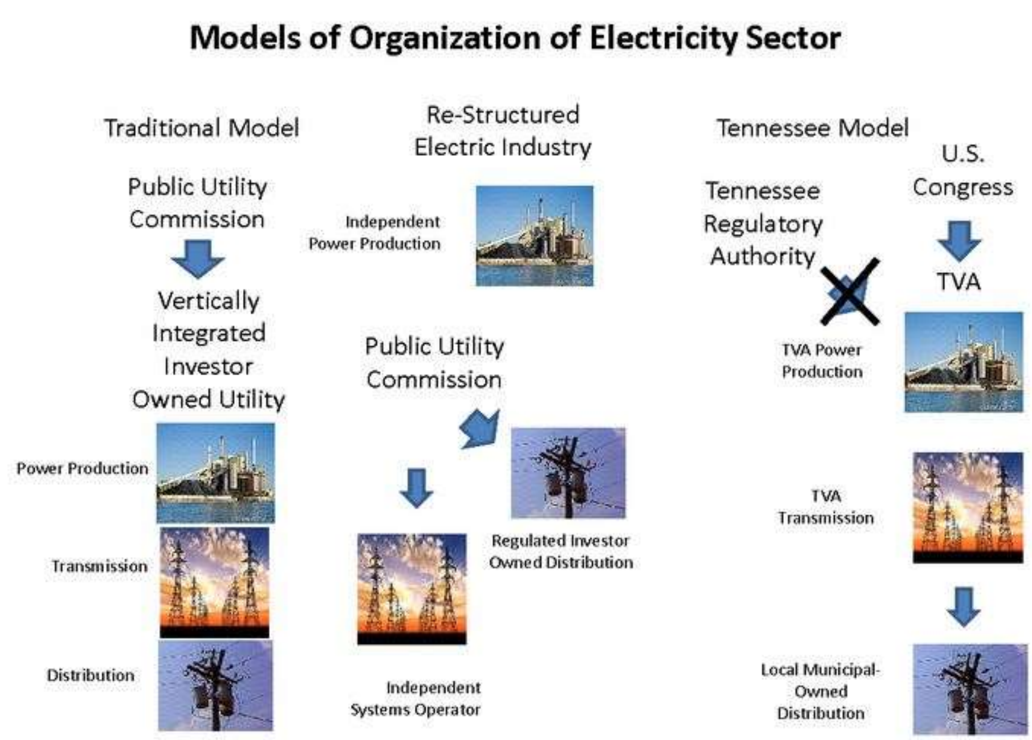

Figure 2.7. Models of Organization of the Electricity Sector in the United States

14 http://www.iea.org/topics/ccs/

These utilities were the sole suppliers of electricity in their jurisdictions. Public Utility Commissions (PUCs) were established to regulate these vertical monopolies to ensure broad access to electricity use and avoid predatory pricing. The PUCs worked with their regulated utilities to set rates, allow those rates to yield reasonable rates of return to investors, and build into rate structures costs for programs that constituted a 'social contract,' i.e. the provision of services that were perceived to be of public value to communities. PUCs also push utilities to develop and adopt integrated resource plans that identify energy resources and technologies to produce electricity cost-effectively but also with respect to community values. In other words, the PUCs are an important mechanism for community values to be reflected in the economic and systems choices of the utilities.

In the 1990s, a number of states enacted legislation restructuring their integrated utility systems in order to promote economic efficiency. In these states, utility companies typically no longer owned all of their own power plants, and the transmission systems were turned over to independent system operators (ISOs). The utilities were left with the distribution systems, which the PUCs still monitored and regulated but not to the extent that they had before. Early in the 21^{st} century, movement toward restructuring ground to a halt because of the Enron debacle in California.[15] (See Figure 2.8 for the current status of electric industry restructuring in the U.S.)

Figure 2.8. Electricity Restructuring by State (2010 White=Not Active Green=Active Yellow=Suspended) **http://www.eia.gov/electricity/policies/restructuring/restructure_elect.html**

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15 http://en.wikipedia.org/wiki/California_electricity_crisis

Funds for social contract programs, such as energy efficiency programs that were deemed to be of value to ratepayers, could still be built into retail electricity rates in a restructured world, though many states have implemented system-benefit charges (i.e. special surcharges) on the transmission of electricity to pay for those programs.[16] Such policies are built on the assumption that all consumers ultimately benefit from energy efficiency programs.

Comparatively, TVA exists and operates under an entirely different model. TVA generates most of the electricity that is used by consumers in Tennessee. It is a federal corporation and as such, the state of Tennessee, through the Tennessee Regulatory Authority (TRA), has no legal authority over its rates, pricing, and electricity supply portfolio, which some states influence through Renewable Portfolio Standards.[17] It also means that the state cannot use its influence as a regulator of a monopoly to require TVA to offer social contract-type programs. This does not mean that TVA does not strive to provide clean and cost-efficient power to its customers, because it does.[18] TVA residential electricity rates are among the lowest in the nation. TVA promotes energy efficiency through its EnergyRight® program.[19] Additionally, TVA is currently in the middle of a comprehensive integrated resource planning process to help it plan its electricity generation portfolio to meet a complicated set of energy, economic and environmental goals.[12]

In summary, **Tennessee, like most states, has no influence over oil, natural gas, and coal markets but, *unlike* most states, also has limited influence over its electricity future**. This has important implications for the state as it considers potential policies that could be included in a state energy plan.

It should be noted that there are many aspects of its operational environment that TVA also does not control. TVA is governed by a board, overseen by the Federal Energy Regulatory Commission (FREC), and ultimately, accountable to the U.S. Congress. It frequently receives input from the state's Congressional delegation, private industry and the public. TVA can enter into long-term

[16] For a description of the New York State systems benefit charge, see http://www3.dps.ny.gov/W/PSCWeb.nsf/All/58290EDB9AE5A89085257687006F38D1?OpenDocument
[17] Renewable portfolio standards (RPS) stipulate the fraction of electric power demand that must be met by renewable resources by some date (e.g., 20% by 2020). See http://www.nrel.gov/tech_deployment/state_local_governments/basics_portfolio_standards.html. It should also be noted that at least 35 states include increasing renewable energy in their state plans: see naseo_state-energy-plan-evaluation_final_5-24.pdf.
[18] The 1933 act that established TVA requires it to keep its rates as low as feasibly possible.
[19] See http://www.energyright.com/programs.html.

contracts for energy resources such as coal, but by-and-large cannot dictate resource prices. TVA's hydro resources are vulnerable to extended droughts. More generally TVA's capital investments, as in nuclear power, place some constraints on its future ability to generate electricity from alternative sources.

TVA operations are governed by many federal environmental laws, such as the National Environmental Policy Act, the Clean Water Act, the Endangered Species Act, and the Clean Air Act and various state laws. Its nuclear operations are overseen by the Nuclear Regulatory Commission. (The Appendix to this report provides a more detailed listing of various entities that affect electricity market outcomes in the state.) The operation of some nuclear and fossil fuel power plants could be impacted by extreme temperatures if the water in the adjacent rivers becomes too hot to absorb hot water discharges from power plants without harming the riparian ecosystem where land meets water. Lastly, while TVA controls most of its electric power production resources, the TVA system is integrated into the larger Eastern Interconnection electric power network (see Figure 2.9).

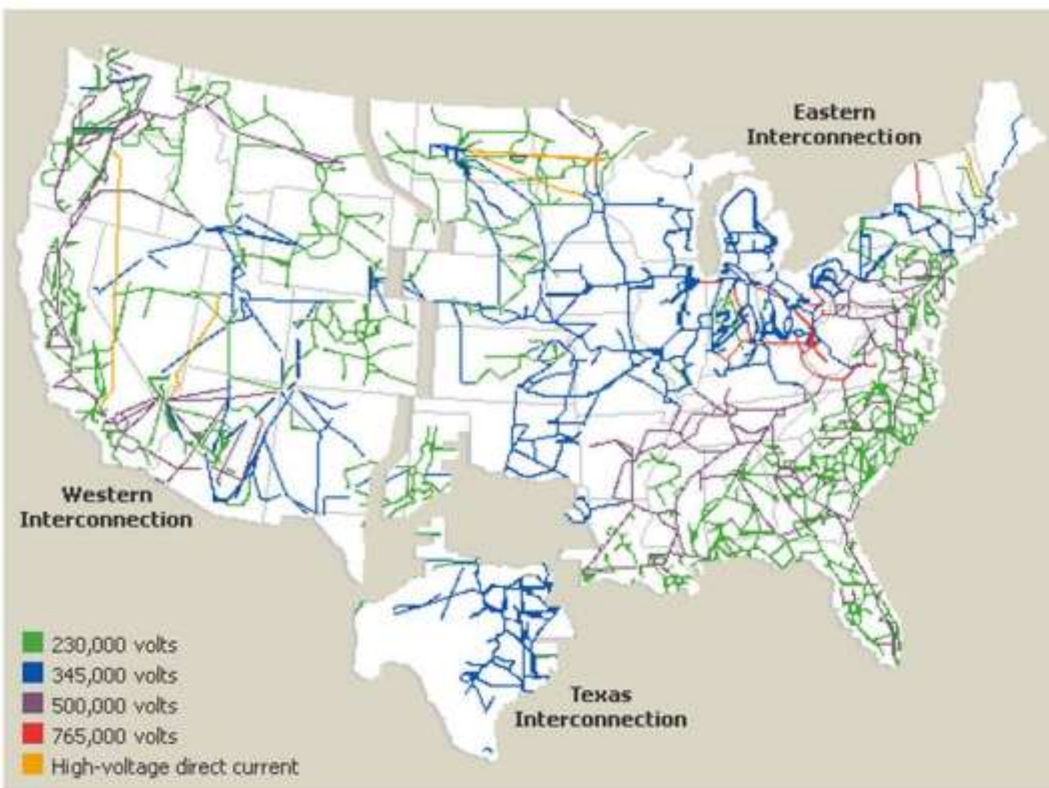

Figure 2.9. Map of the U.S. Electrical Grid, Divided into Three Separate Components. http://www.geni.org/globalenergy/library/national_energy_grid/united-states-of-america/americannationalelectricitygrid.shtml

Neither Tennessee nor TVA has any direct control over this larger network. Connection to the Eastern Interconnection allows TVA to buy and sell power resources in the spot market, though its governing law restricts its spot market sales and it only infrequently buys electricity on the spot market.[20] This connection exposes the TVA system to small risks of reliability events and outages outside its own area that could, and occasionally have, cascaded through substantial sections of the eastern seaboard. It should be noted that TVA is recognized for the high reliability of its system and its ability to shield its system from external reliability events.

TVA is also unlike the traditional vertically integrated utility because it does not distribute electricity locally. In the TVA region, approximately 85 percent of the power produced by TVA is distributed to customers through 155 local power companies (LPCs), municipal utility companies and cooperatives. The LPCs are responsible for maintaining the local electricity grid. They also work cooperatively with TVA on a number of programs. For example, they work closely to coordinate policies and approvals for rooftop solar installations. The LPCs are partners in the Tennessee Valley Power Producers Association.[21]

Other Key Components: Nuclear Power, Renewables, and Energy Efficiency

Nuclear Power

Nuclear power provides a substantial amount of electric power in the U.S. and is a key component of the TVA electric power production portfolio. Though the world price of uranium has been volatile in recent years (Figure 2.10), overall the price to produce electricity once a nuclear power plant comes on line has been fairly stable.

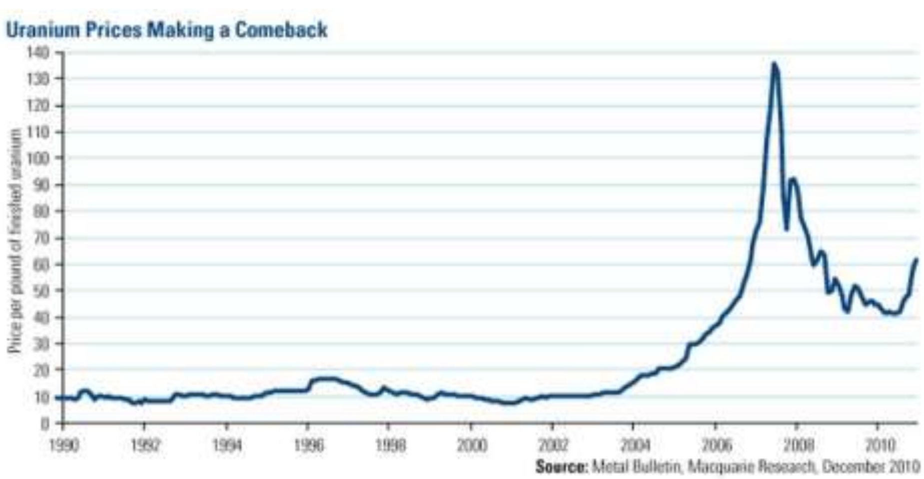

Figure 2.10. World Uranium Prices Over Time http://www.usfunds.com/investor-library/investor-alert/investor-alert15/#.VCRws0Z0xjQ

[21] http://www.tvppa.com/Pages/default.aspx.

Groundbreaking on new nuclear power plants stopped in 1974 for various reasons, including: negative public perceptions of nuclear power post-Three Mile Island and Chernobyl; a time consuming, expensive, and inherently uncertain regulatory process that makes planning difficult; uncertain construction costs and potential inability to spread the risks of those costs beyond private sector investors; and uncertainties with respect to new, breakthrough energy sources and technologies that could render new nuclear power plants relatively economically uncompetitive. [22] It should be noted, though, that TVA's Watts Bar 2 nuclear reactor is expected to become operational in 2015 if an issue with the Nuclear Regulatory Commission about nuclear waste issues can resolved.[23] This will be the first new reactor to go on-line in the U.S. in the 21st Century.[24]

Renewable Energy

The main renewable energy resources are hydro, biofuels, wind, and solar.[25] Hydro is the predominant and most well understood renewable energy resource. On average, fourteen percent of TVA's power is generated by hydro-electric dams, which is an important foundation of its load-following and peak-load capacity.[26] These plants are technically reliable, and the price of electricity generated by dams is quite stable and predictable. Two issues currently associated with hydro are:

1) It has hit its peak of production in the U.S. because there are few promising sites for new dams
2) Concerns are increasing about the productivity of the dams due to silting and water supply constraints.

Biofuels have an important place in the American energy sector and may be a fruitful source of economic development benefits for Tennessee. The biofuels market is currently dominated by ethanol derived from corn. Ethanol is combined with gasoline refined from petroleum for purposes of fueling automobiles, and may help reduce American dependency on imported oil. Indeed, this has been successful as corn ethanol meets approximately 7.1 percent of the transportation sector's

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[22] http://en.wikipedia.org/wiki/Nuclear_power_in_the_United_States.
[23] https://www.google.com/#q=TVA+waste+confidence+august+2014.
[24] http://www.wbir.com/story/news/local/2014/07/24/watts-bar-2-nuclear-reactor-assemble/13129195/.
[25] See the chapters below for a more focused discussion of these resources within Tennessee.
[26] http://www.tva.com/news/releases/julsep13/Fact%20Sheet%20-%20TVA%20Renewable%20Programs.pdf

energy needs.[27] However, the use of corn ethanol is controversial to some because it displaces food production, causes volatilities in food prices (see Figure 2.11), may exacerbate environmental issues associated with its production (e.g., soil erosion, runoff of pesticides and herbicides into drinking water supplies), and may have a net zero or even negative "energy balance" (i.e., some believe it takes more energy to produce a gallon of corn ethanol than is actually embodied in a gallon of corn ethanol). There are also concerns about the reliability of corn ethanol supplies given various climate change impacts on growing seasons, extreme weather events, and water availability. Alternative sources of biofuels, such as cellulosic ethanol and algae, are not yet economically viable.

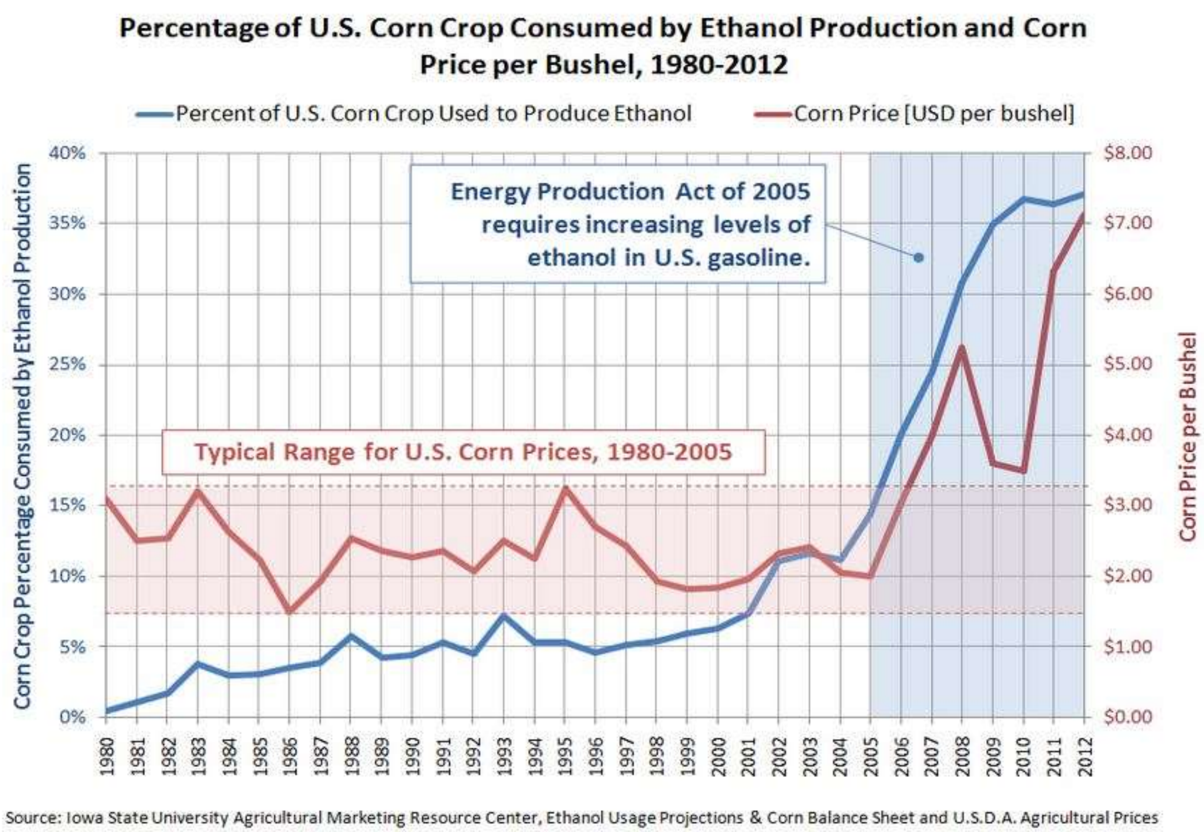


Figure 2.11. U.S. Corn Crop Production Consumed by Ethanol Production and Corn Price per Bushel
https://www.extension.iastate.edu/agdm/crops/outlook/cornbalancesheet.pdf

Wind power has increased tremendously in the U.S. in recent years (Figure 2.12). The price of electricity produced by wind turbines is now comparable to the price of electricity produced by conventional fossil-based plants. Wind technology is becoming even more affordable and efficient. Of course, an important concern with respect to wind is that it is intermittent and is without energy

[27] http://www.ers.usda.gov/data-products/us-bioenergy-statistics.aspx. The success of corn-based ethanol has been driven partly by the renewable fuel standard in the 2005 Energy Policy Act and subsequent legislation. See http://www.epa.gov/otaq/fuels/renewablefuels/

storage capabilities and thus is not suitable to support electricity demand on an ongoing basis. The current U.S. electric grid, including the TVA system, can only handle intermittent renewable energy resources up to about 20 percent.[28] While this threshold is not yet close to being hit in most of the U.S., it is an issue that concerns systems operators. Thus, future prospects for wind are dependent to a large degree on advancements in smart grid technology and energy storage technologies. Wind generation is not significant within Tennessee, but TVA does purchase power produced by wind from outside its region. However, intermittent wind could become an issue in other areas of the Eastern Interconnection or become an issue if wind power from other areas in the country, such as Texas and Oklahoma, finds its way to TVA.[29] Wind *technology* is an international market; three transnational companies currently dominate the market: General Electric, Siemens, and Vestas.

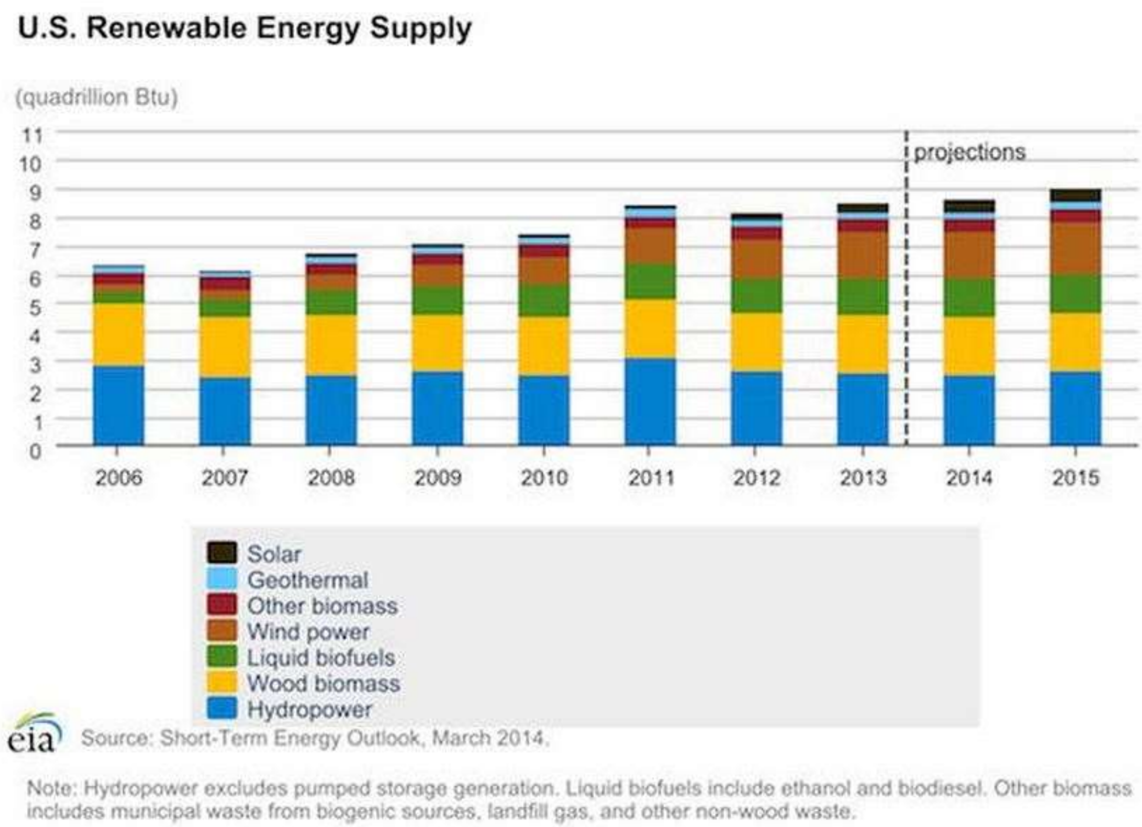


Figure 2.12. U.S. Renewable Energy Supply http://www.eia.gov/forecasts/steo/report/

Solar has two major incarnations: decentralized (e.g., rooftop) and central systems. Like wind, these technologies are also produced and sold in a global market. The latter type of system is found most often in desert environments and focuses light (reflected from mirrors for example) to heat water to

[28] Talbot, D. 2009. Lifeline for Renewable Power. *Technology Review*, Vol. 112 (1), 40-47.
[29] http://www.timesfreepress.com/news/2013/apr/21/harness-wind-clean-line-energy-partners-eyes.

produce steam. The most common type of the former is rooftop photovoltaic (PV) systems. In these systems, light hits solar panels, which then produces an electric current. Costs for both types of systems are falling. Because of competition from China, the cost of solar panels has plummeted in recent years (Figure 2.13).

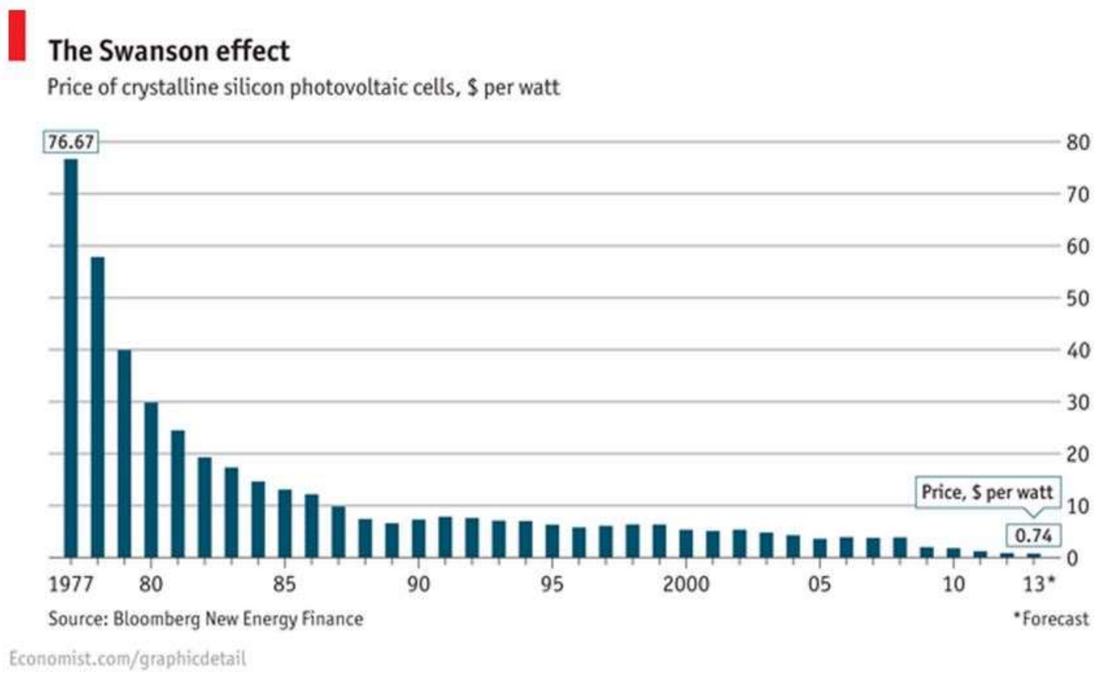


Figure 2.13. Price of Silicon Solar Cells over Time
http://financialconservation.blogspot.com/2013/01/the-swanson-effect-pricing-sunshine.html

Solar power is intermittent, just like wind. TVA is closely controlling the growth of decentralized PV in its region through a mix of feed-in tariffs,[30]annual caps for new small scale decentralized PV, and installation approvals.[31] It should also be noted that local municipal utilities and governments have many requirements that must be met before allowing the installation of rooftop PV (e.g., building codes with respect to electrical systems, historic preservation regulations). A study by the National Renewable Energy Laboratory found that only about 22 to 27 percent of U.S. homes have the characteristics needed for a rooftop PV system.[32] Common constraints include trees blocking the

[30] These are prices paid to generators of distributed power for each unit of electricity (i.e., kilowatt hour) contributed to the grid. TVA has a feed-in-tariff for rooftop solar. See http://www.tva.com/greenpowerswitch/providers/.
[31]It should also be noted that in addition to TVA's approval, approvals are also needed from the local power company and possibly municipal building code inspectors, zoning commissions, and historic preservation programs.
[32] http://www.nrel.gov/docs/fy09osti/44073.pdf

sun, rooftops not facing south, lack of rooftop space, and roofs in ill repair and otherwise not able to support the weight of the PV systems.

Energy Efficiency

All aspects of all energy systems can be made more efficient and as noted in the next chapter of this report, there is a huge amount of waste currently associated with the state's energy sector. Energy efficiency generally refers to reducing energy consumption while sustaining or even improving the functional quality of the end uses, such as space heating, refrigeration, water heating, clothes washing and drying, and lighting. Overall, over time, the energy efficiency of end-use technologies has increased and is continuing to increase (see Figures 2.14 and 2.15).

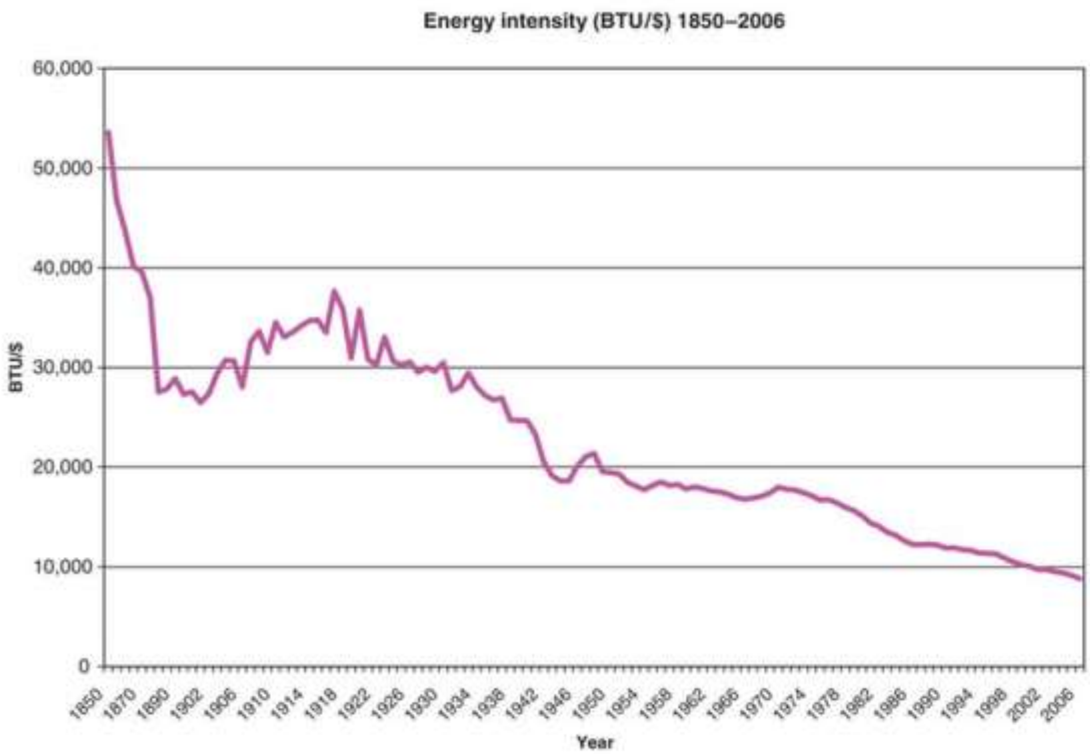
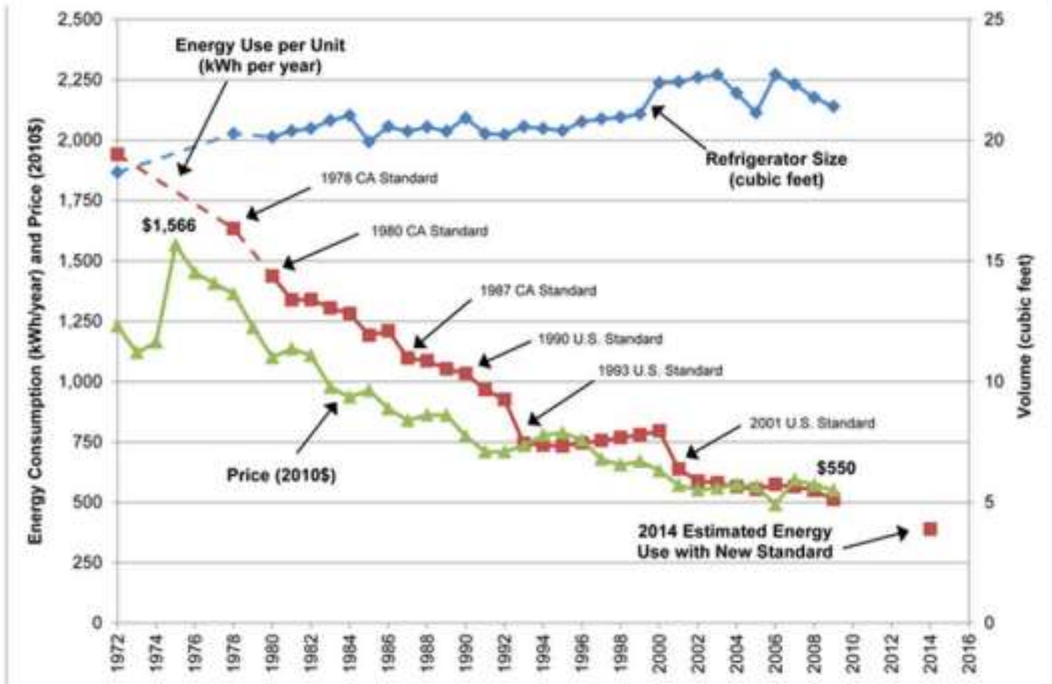


Figure 2.14. Illustrates Improvements in Energy Efficiency Over Time
https://www.nae.edu/Publications/Bridge/EnergyEfficiency14874/ThePotentialofEnergyEfficiencyAnOverview.aspx



Sources: Association of Home Appliance Manufacturers (AHAM) for energy consumption and volume; U.S. Census Bureau for price

Notes: a. Data includes standard-size and compact refrigerators.
b. Energy consumption and volume reflect the DOE test procedure published in 2010.
c. Volume is adjusted volume, which is equal to the fresh food volume + 1.76 * freezer volume.
d. Prices represent the manufacturer selling price (e.g. excluding retailer markups) and reflect products manufactured in the U.S.

Figure 2.15. Illustrates Improvements in Refrigerator Energy Efficiency Over Time
https://www.ase.org/sites/ase.org/files/AHAM_Refrigerator-Graph_July_2011-1-.pdf.

The prices for these new and improved technologies, both first cost (i.e. purchase cost) and life cycle costs (i.e., the total costs for purchasing, operating, and maintaining a technology, including fuel costs over the course of its useable life), are decreasing. The market for these technologies, like energy efficient LED lights, is international as the companies and manufacturing plants for energy efficient technologies are located throughout the world. In this sense, the state of Tennessee has no influence over the prices of energy efficient technologies or its essential pace of progress. However, in principle the state can, through various policies, influence product adoption and potentially where these products are produced.

Energy efficiency also extends to buildings. Various groups are promoting more efficient and sustainable building designs, such as the Leadership in Energy Efficient Design (LEED) program promoted by the U.S. Green Building Council.[33] LEED certifications are available for new commercial, institutional, and residential buildings. There are also many efforts underway to

33 http://www.usgbc.org/leed

retrofit existing buildings, including in Tennessee where there is growing interest in the energy efficiency of the state-owned building stock. The U.S. Department of Energy (DOE) administers a national program to retrofit low-income homes, called the Weatherization Assistance Program (WAP).[34] DOE also administers the Home Performance with ENERGY STAR Program, which focuses on the non-low-income residential sector.[35] To meet various goals, state PUCs often direct their utilities to run and/or financially contribute to both low-income and non-low-income residential retrofit programs. It is within the purview of the state of Tennessee to incentivize the construction of new energy efficient buildings and the retrofitting of existing buildings. This can reduce ongoing household utility bills, freeing up purchasing power, and make businesses more competitive as well. As noted above, TVA and the LPCs offer a range of energy efficiency programs to Tennessee customers.

Other Issues

There are numerous other issues that should be mentioned to complete this discussion of the current energy system in the U.S. An important issue not yet mentioned is the electric transmission system, which in many places in the country is aging and overloaded,[36] though this is not an issue in Tennessee. New transmission capacity is difficult to build because of siting issues; many people for various reasons do not want transmission lines running through their backyards. Many people also object to the obstruction of scenic views and forfeiting land to right-of- ways for the new lines. Eminent domain powers (be they federal, state or local) can be used to acquire rights to locate new transmission towers and lines, but use of these powers is growing more controversial. It also should be noted that the oil and natural gas pipeline infrastructure in the U.S. is badly in need of maintenance. In a recent report card on the nation's entire infrastructure, the American Society of Civil Engineers gave the U.S. energy infrastructure a D+. [37]

[34] http://energy.gov/eere/wipo/weatherization-assistance-program.

[35] https://www.energystar.gov/index.cfm?fuseaction=hpwes_profiles.showsplash.

[36] http://www.washingtonpost.com/local/trafficandcommuting/aging-power-grid-on-overload-as-us-demands-more-electricity/2012/08/01/gJQAB5LDQX_story.html; see also http://www.energy.gov/sites/prod/files/2014/08/f18/NationalElectricTransmissionCongestionStudy-DraftForPublicComment-August-2014.pdf.

[37] See http://www.infrastructurereportcard.org/energy/.

Game Changers – Energy Technology

Technology is advancing at an ever-quickening pace. Advancements in energy technologies are being matched by advancements in various complementary technologies, including information, bio-, and nano-technologies. New science and technologies are converging in many areas related to energy. It is useful to consider technological game changers because the state can consider policies that well position its energy and economic sectors to take advantage of these potential new developments. Here are three game changers that pertain to the transportation sector.

Battery Technology

This is an extremely hot topic for R&D and a particularly fertile area for new advancements. The ultimate goal is to develop vehicle batteries that have an extended range, say 400 miles, can be recharged in a matter of minutes, and are safe (e.g., do not catch fire) and reliable. If such vehicle batteries can be developed and are affordable, then the automobile industry would be revolutionized. One can imagine that the internal combustion engine would be quickly displaced by electric vehicles. Companies such as Tesla and Nissan in Tennessee[38] are leading the way in this market. With respect to the state of Tennessee, this revolution would require a change in infrastructure (adding charging stations and/or retrofitting existing service stations for fast battery recharging). Also, an alternative to the current gas tax, which is used to fund highway and road projects, would need to be found.[39] There would also be important consequences for the state's private transportation equipment sector that includes visible producers like Nissan, General Motors and Volkswagen.

Advanced Biofuels

It is possible that biofuel alternatives could out-compete electric vehicles in the mid-term to determine the future fuels for the transportation sector. To make this happen, supplies of ethanol from corn feedstock would need to be substantially augmented by biofuels from cellulosic feedstock and from algae and other micro-organisms. Algae are a particularly intriguing source of biofuels.[31] Imagine thousands of acres of algae laden ponds managed to produce a range of biofuels. Some believe that algae solutions could power a substantial portion of the U.S. transportation sector. If advanced biofuels win this competition, then the current transportation fuel infrastructure would not have to appreciably change and vehicles would still have internal combustion engines. Because

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[38] Nissan's expansion in TN – see http://www.plugincars.com/nissan-readies-factories-tn-increase-leaf-production-127933.html.
[39] For a proposal for restructuring the gas tax see http://www.itep.org/itep_reports/2013/09/a-federal-gas-tax-for- the-future.php?gclid=CNzj9e3mosECFVNk7AodAUsA0w#.VDgxL7l0zIU.

biofuels are likely to be bought and sold in more regional markets and with its traditional role as an agricultural leader, Tennessee could be a player in this game. The gas tax would not be at risk in this scenario. It should be noted, though, that emission and environmental impacts from biofuels require additional research and assessment.

Hydrogen Fuel

The transportation sector could head in a third direction in the longer-term, towards using hydrogen as the fuel of choice for vehicles. When hydrogen and oxygen combine in a fuel cell, the process results in an electric current that can be used to power an electric engine. The only emission from a fuel cell vehicle is water. We know how to produce hydrogen (e.g., through electrolysis), and how to build fuel cells. The main issue is cost. Fuel cells are still very expensive relative to conventional vehicle technology. It would be extremely expensive to build a completely new infrastructure to produce, transport, and distribute hydrogen (for example, would gas stations be replaced by hydrogen stations?). Also, there are various additional technical issues. For example, the technology to store hydrogen in a vehicle is not ready (hydrogen 'gas' tanks are leaky, not much hydrogen can be stored in the tanks, and retrieving the hydrogen quickly from the tanks is challenging). Though this path seems less likely than the other two, if it were to come to pass, Tennessee would need to deal with major infrastructure issues and could also could benefit economically because the production and distribution of hydrogen would likely be done in regional markets. One can imagine that a hydrogen tax could be gradually instituted as the sun sets on the gasoline tax.

There are technology game changers on the electricity side as well. Similar to the transportation sector scenarios, the two mentioned below are fairly disparate.

Distributed Generation (DG)

The term distributed generation encompasses the many ways that electricity and/or heat can be generated in small amounts on-site at scattered locations. These systems are typically not owned by the utility company and may or may not be connected to the grid. The most common DG technology is rooftop solar . Major retailers such as Walmart and Kohl's have embarked on aggressive programs to place rooftop solar on their stores. Many manufacturers, such as Campbell's Soup Company, are also using PV solutions. Manufacturers and others also combust waste materials on-site (i.e., waste-to-energy), may tap nearby landfills for methane, and power their plants using combined heat and power stations and/or geothermal technology. As part of a research study being conducted by the Baker Center on DG, various businesses revealed in phone interviews that using DG allowed them to control their energy costs and increased the reliability of their electricity (Hurricane Sandy was mentioned several times as a motivator to move to DG).[40]

The common denominator across the DG technologies is that they reduce the demand for electricity from the local electricity distributor or eliminate the need altogether if the site goes off-grid. Utilities like TVA are increasingly focused on understanding the growth of distributed generation, which could impact the fixed costs of the electric power system and how those costs are reflected in electricity rates charged to customers.[41] In the extreme case, DG solutions could result in idled infrastructure and stranded utility costs. Thus, there is a need to understand what customers benefit with respect to DG, and how TVA, the LPCs and customers can work together to accrue the benefits from DG while also ensuring that all of the systems customers continue to receive reliable and affordable power.

Electricity Production Revolution

There was a time when proponents of nuclear fission power plants envisioned a world where electricity was too cheap to meter. While major advancements have benefitted electric power production, that vision was not realized. Yet, as we move further into the 21st century, it is possible to envision a world where centrally-produced electricity dominates the energy landscape of the U.S. However, in order for this to happen, some combination of the following advancements would be needed:

- **Improved nuclear power** – There are new designs for conventional fission plants that are safer and more reliable. Some believe that the future of nuclear power lies with small modular reactors (SMRs) that could be co-located at existing generation sites to begin with and then in other locations as their safety and reliability are demonstrated. Others believe in the promise of nuclear fusion, where instead of splitting atoms the technology fuses atoms together to produce power. Proponents believe that magnetic confinement fusion technology is close to a self-sustaining reaction that produces more power outputs than inputs needed to initiate the reaction. Inertial confinement fusion, which uses lasers to heat up the target materials, is a bit further behind. It should be noted that commercial, cost competitive fusion power still appears to be a long-term goal.

[40] Results from these interviews will be released by the Baker Center in 2015.
[41] http://www.forbes.com/sites/pikeresearch/2013/08/26/distributed-generation-poses-existential-threat-to-utilities/.

- **Superconducting transmission and distribution lines** – The current transmission and distribution systems are inefficient. The U.S. EIA estimates that the losses average around 6 percent.[42] Material science researchers have discovered materials that can transmit electricity with virtually no loss of energy, also known as superconductors. The problem presently is that most superconducting materials have to be cooled to many degrees below zero Celsius. If 'room temperature' superconducting materials can be discovered, they could revolutionize the transmission and distribution of electricity.[43]
- **Efficient large-scale energy storage** – To a large degree, expansion of renewable resources for central-scale electricity generation depends upon advances in energy storage. Several potential solutions are undergoing research and development, including massive flywheels, pumped-hydro (which TVA is already using at Raccoon Mountain), compressed air (which TVA is on record as considering[44]), and electrochemical capacitors.[45] Some even envision a world where energy is stored in the batteries of electric vehicles during the night.
- **Smart grid** – This technology essentially ties together all power generation sources (including fossil fuels, renewables and energy storage) transmission and distribution systems, and electricity demands by end use and time-of-day. Smart grids would anticipate the availability of wind resources minute-by-minute, for example, as well as demand from every customer connected to the grid. To meet demand, various sets of power production resources would be employed, from baseload to very short-term peak load resources to the timely release of energy from a portfolio of energy storage facilities. At times, prices would be dynamically set to shave peak demands. Some customers might even allow the 'smart grid' to shut off various end uses for limited periods of time (e.g., increase the cycle times of furnaces for instance). One can image that the smart grid would be integrated with users' computers and mobile devices.

A new electricity system with these types of components could benefit Tennessee's customers, from lowering prices to providing more reliable power. Still, the state's influence in this scenario would be limited because most of the action would happen under the purview of TVA, though the local power companies would also be an important player in this scenario. However, an advantage that

[42] http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3
[43] A cost-effective interim solution could be direct current long-distance transmission lines.
[44] http://www.tva.com/environment/technology/compressed_air.htm
[45] http://energy.gov/oe/services/technology-development/energy-storage

the state does have is that many of its research institutions, including the University of Tennessee and Oak Ridge National Laboratory (ORNL), are leaders in these technology areas. A collaboration between the state, TVA, the LPCs, and ORNL and other research institutions to take advantage of energy technology game changers could prove quite valuable.

Game Changers – Demographics and Technology

There are significant demographic and non-energy technology trends that could radically change either the profiles of energy demand and consumption and/or the overall magnitude of energy needed by the state. Let's start with several major demographic trends.

The business-as-usual population forecast for Tennessee is that the population will increase from just about 6.5 million residents to over 8 million by 2040. Energy supply and demand will shift to adjust to the changing needs of this population. However, everything may not be equal. For example, society is aging. The number of residents over 65 years of age will increase as well the percentage of the population past this age. There is some evidence to suggest that elderly households demand more energy than non-elderly households per capita, which would result in an even higher energy demand in the future.[46] Additionally, household size continues to decrease and the number of single person households continues to increase.[47] This trend means that there will be a need for more housing units per capita in the future, with more demand for space heating and cooling in particular. Thus, these three demographic trends could result in very substantial increases in energy demand within the next several decades.

Non-energy technology trends may have a mixed impact upon overall energy use in Tennessee. For example, if the number of workers who telecommute continues to grow, albeit rather slowly,[48] continued increases in Internet bandwidth, the rise of cloud computing, and advances in other productivity-enhancing technologies could accelerate telecommuting. A result could be a reduction in transportation energy demand but an increase in residential energy consumption. Consumers are increasing their purchases of products over the Internet. Instead of driving to the mall to purchase products and transport them home in their vehicles, consumers purchase a wide range of

[46] Tonn, B. and Eisenberg, J. 2007. "The Aging U.S. Population and Residential Energy Demand," *Energy Policy*, Vol. 35, 743-745.

[47] Klinenberg, E. 2012. *Going Solo: The Extraordinary Rise and Surprising Appeal of Living Alone*. Penguin Books, New York.

[48] http://www.globalworkplaceanalytics.com/telecommuting-statistics.

products from a wide range of vendors, which are then delivered to their homes. In this world, some trips are reduced while others are increased. A next step along this path is for individuals to manufacture products in their own homes using 3D printing. Again, trips to the store are reduced and also in this case, so are needs to transport and warehouse various products. On the other hand, presently, on average it takes more energy to produce a widget using 3D printing than is needed for a conventional manufacturing process.[49] Research is needed to clarify impacts of these trends on both overall energy demand and when and where energy demand occurs.

Game Changers – Threats

Uncertainties abound surrounding Tennessee's energy future. As noted above, many aspects of this future are beyond the control of the state of Tennessee. Oil and natural gas prices can be expected to continue to be volatile, the magnitude dependent upon numerous external factors. Renewable energy resources and distributed generation will continue to make strides but the paces of adoption are uncertain. In addition to identifying major technological and demographic game changers, thinking broadly and deeply about energy futures requires a consideration of major threats that could change the energy game.

Climate Change

Climate change has the potential to impact numerous components of the energy system. Increased temperatures could increase peak demands for air conditioning in the TVA region, and as noted above, possibly impact electric generation options. More numerous and severe weather events could more frequently disrupt the delivery of electric power to homes and businesses. Loss of reliable power could push many more toward DG systems. The impacts of climate change may be more severe in coastal areas, which need to deal with sea level rise and local flooding, and in desert areas that may suffer from ever-greater water shortages. These impacts in other areas of the country could actually impact Tennessee if people in large numbers migrate from those areas to Tennessee. [50]

Major Accidents

Accidents at nuclear power plants turned public perception against nuclear power. The signature event was the accident at Three Mile Island in 1979. The horrendous accident at Chernobyl and the

[49] Olson, R. 2013. 3D Printing: A Boon or a Bane, *The Environmental Forum*, Vol. 30 (6), 34-38.

[50] Tennessee was indeed a destination for many displaced by Hurricane Katrina. Also, in part because of concerns about extreme weather, many 'half-backers' (migrants from the north to Florida), are settling in Tennessee

more recent one at the Fukushima plant in Japan continue to raise safety issues with respect to nuclear power. While the causes and ultimate consequences of these three events were quite different, public perception about the safety of nuclear power may not make any distinctions. Another serious accident in the U.S. could push back if not derail re-development of the nuclear sector in this country, which could be a serious issue for TVA. Nuclear power is not the only energy system component vulnerable to public opinion reactions to accidents. Drilling for oil in the Gulf of Mexico and in Alaska was threatened by the Deepwater Horizon and Exxon Valdez oil spills, respectively. Biofuels production by algae created by synthetic biology could be threatened if man-made genes escaped into wild populations of algae and created havoc in aquatic ecosystems across the country. Another major earthquake centered on the New Madrid fault could also cause widespread damage to Tennessee's energy infrastructure.

Terrorism

Many components of the world's energy system are vulnerable to terrorist attacks. These attacks could cripple important components, which in turn could have consequences for the state of Tennessee. The central electricity grid is vulnerable in many ways. NATO warplanes demonstrated this during their attacks on Serbia's electric grid, dropping highly conductive filaments to short-circuit live electric power lines. Transmission towers, power plants, substations, and dams are also vulnerable to physical attack. Analysts are also worried about cyber-attacks on the grid. Attacks anywhere in the Eastern Interconnection could disrupt power to Tennessee's customers. Frequent disruptions, or even the threat of disruptions, could hasten the move towards DG. Energy analysts have also been worried for some time about terrorist attacks on Middle Eastern oil fields and tanker shipping lanes.

Conclusions

The world energy system is multifaceted and complex. Through its many components and processes, over the past several decades the energy needs of Tennessee's residents and businesses have generally been met. However, the **state of Tennessee has little to no control over major aspects of this system.** The state cannot control the prices or availability of oil products or natural gas, for instance. Not only are energy markets global, but the production of energy technologies, from nuclear reactors to energy-efficient products, is global as well.

The state can influence energy consumption as well as many economic aspects of energy technology R&D and manufacturing. For example, policies designed to increase the efficiencies of end uses can help to reduce vulnerabilities to energy price and supply volatilities. The state's agricultural heritage provides the foundation for initiatives in the area of biofuels that might be utilized for further economic development gains**. The state's advanced research and development organizations, such as ORNL and the University of Tennessee, Knoxville,** already provide a strong foundation for innovative economic development and can be increasingly leveraged to support new business development. **The state has limited resources to expend on the energy sector and must make its decisions carefully and wisely.**

CHAPTER 3. ENERGY FLOWS AND CONSUMPTION IN TENNESSEE

By Jean Peretz, PhD & Charles Sims, PhD, Howard H. Baker Jr. Center for Public Policy

Key Points

An **overview of energy consumption in Tennessee by primary energy source** (e.g., coal or nuclear) **and end-use sector** (e.g., residential or transportation) is covered. A *Sankey diagram* is used to present the nature and complexity of energy consumption in Tennessee. Methodology developed at Lawrence Livermore National Laboratory (LLNL) on rejected energy (i.e. energy losses) and inefficiencies in each end-use sector is the basis for this examination. So that comparisons can be made across specific fuel sources, such as comparisons of hydroelectric power with natural gas, a common unit of measure is used, British thermal units (Btu). Data collected by the U.S. Energy Information Administration (EIA) are generally used, unless otherwise noted. The latest publicly available data were used (2012); we anticipate that changes in fuel mix will occur over the next few years as TVA converts some coal-fired plants to natural gas.

- **Petroleum is largest primary energy source** used in the state, followed by coal.
- Most of the **energy consumed in Tennessee is in the transportation sector,** followed by industrial uses.
- **Petroleum as a percentage of energy consumed has decreased** despite an increase in vehicle miles traveled and car registrations.
- **Coal flows mostly to electricity generation**, although a small percentage goes directly to uses in the industrial sector.
- **Tennessee is more reliant on coal** as a primary energy source than the U.S. as a whole.
- **Coal as a primary energy source is declining** in Tennessee due to a variety of factors.
- **Tennessee is a net importer of electricity** because in-state consumption exceeds production.

Introduction

This chapter provides a thorough review of energy consumption in Tennessee by primary energy source and by end-use category. This analysis captures the full range of energy supplies and consumer demands. The discussion begins with a broad overview of energy sources and uses and then addresses each individual energy source in turn. The final section of the chapter provides details on broad energy consumer groups in Tennessee.

A synopsis of energy supply and demand is presented in Figure 3.1 where estimated energy flows in Tennessee are shown via a Sankey diagram.[51] The principle of a **Sankey diagram is to represent energy flows beginning with primary sources of energy, such as natural gas or coal, and then show the progression from those primary sources to various end user groups--residential, commercial, industrial, and transportation consumers.** The figure highlights the range of primary energy use by the width of the bands as well as how the energy is consumed. A common unit of measure, British thermal units (Btu), is used so that comparisons can be made across energy sources (e.g., nuclear and hydro).[52] This single figure provides a broad but comprehensive summary of energy use in Tennessee.

Flows can occur through (1) transformation or conversion of a primary source to electricity generation or (2) a direct route, e.g., petroleum to the transportation sector.[53] There are substantial inefficiencies in the conversion of primary sources of energy to end user. "Rejected" energy (losses) occur at each stage. These inefficiencies are primarily a byproduct of the thermodynamic process.[54] They may arise in a variety of ways, including electricity losses on electrical transmission lines and waste heat from a home appliance.[55] As shown in Figure 3.1, the **scope of inefficiency and rejected energy exceeds actual energy consumption** in the state. Electric utility energy efficiency programs are about one-half to one-third the cost of new electricity generation.

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[51] Our approach follows the methods used by Lawrence Livermore National Laboratory in their development of energy flows for all states in 2008. A.J. Simon and R.D. Belles, January 2011. *Estimated State-Level Energy Flows in 2008, United States.* California: Lawrence Livermore National Laboratory. https://flowcharts.llnl.gov/content/energy/energy_archive/energy_flow_2008/2008StateEnergy.pdf. Accessed August 1, 2014.

[52] Primary energy sources are measured by applicable physical units (e.g., short tons, barrels, or cubic feet) and heat content. However, summary statistics for energy consumption are expressed in Btus so that comparisons across primary fuel sources can be made—Btu represents the common denominator for comparison. Therefore, the summary numbers are expressed in Btus but fuel-specific information presented below will appear in physical units.

[53] Electricity will be discussed more fully in Chapter 4. There are also electricity imports into the state because Tennessee consumes more electricity than it generates.

[54] The second law of thermodynamics states that no conversion from one form of energy to another is completely efficient and the consumption of energy is an irreversible process.

[55] "Americans using more energy according to Lawrence Livermore analysis," April 2, 2014. https://www.llnl.gov/news/newsreleases/2014/Apr/NR-14-04-01.html#.VBcp81eK2Vs. Accessed July 9, 2014.

There are four broad end user consumer groups for energy. Transportation uses include the movement of goods and people by means of motor vehicles, airplanes, rail, ship and so on. Residential uses occur at single family homes or multi-family apartment complexes for things like heating, cooling and cooking. The commercial sector includes buildings for such purposes as education, health care services provision, retailing (enclosed and strip malls), and warehousing, among others. Industrial uses encompass energy consumed at manufacturing facilities.

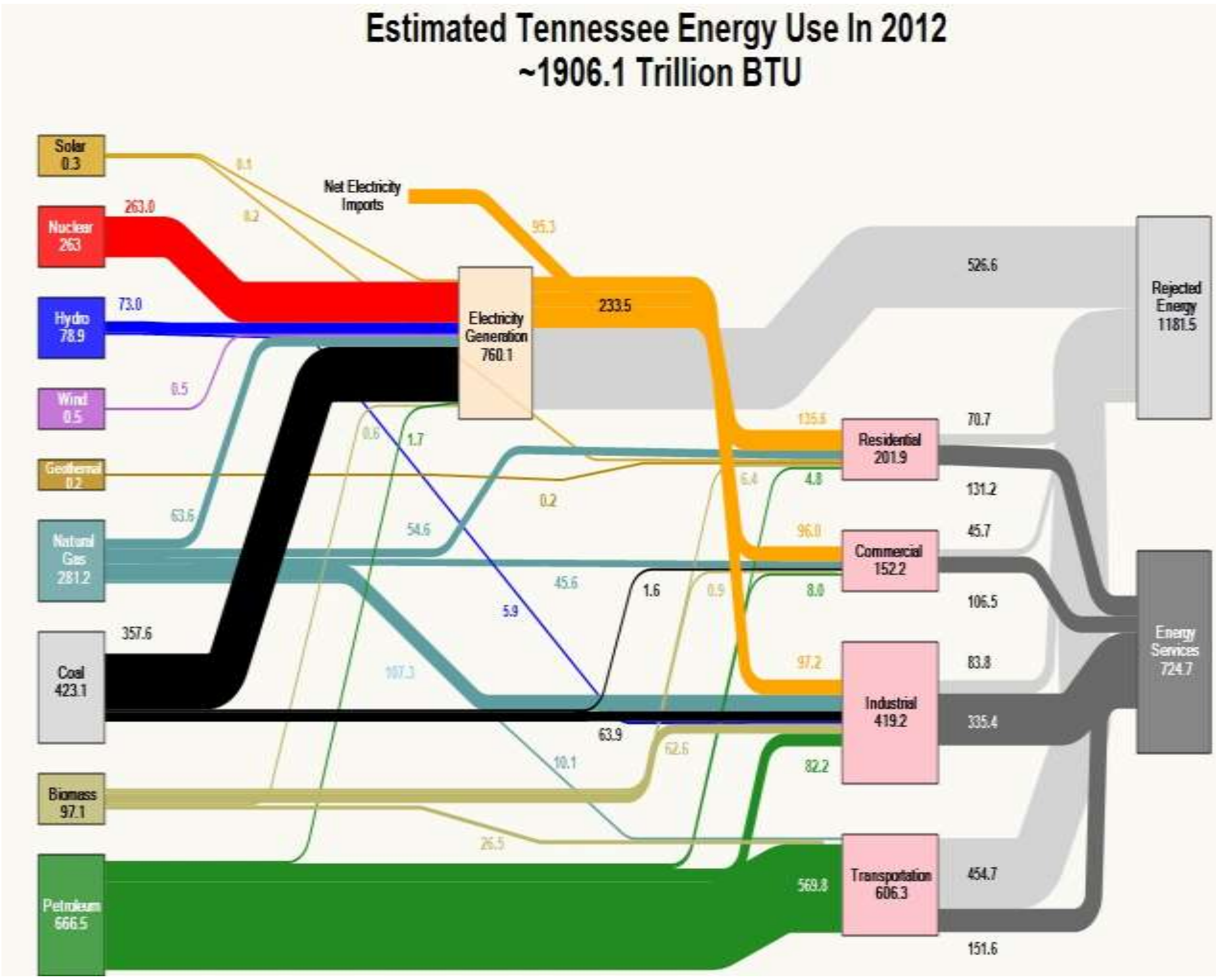

Figure 3.1. Sankey Diagram of Energy Flows in Tennessee, 2012

Energy Consumption Data

The data presented in Figure 3.1 are based on annual energy consumption numbers collected by the U.S. Energy Information Agency (EIA). Using the methodology developed by LLNL, Tennessee's estimated energy use in 2012 was 1,906.1 trillion Btu. The LLNL framework begins with a summation of primary energy by source.[56] Added to that total is net electricity imports calculated for Tennessee. Although Tennessee's total energy consumption is declining, its 15th ranking has not changed. This indicates that consumption in other states is also declining over time. Tennessee uses a mix of non-renewables (fossil fuels such as petroleum and coal) and renewables (primarily hydro and biomass) as its primary sources of energy.

Primary Fuel Sources of Energy Consumption

For a more detailed explanation of the primary sources of energy in Figure 3.1 and their energy flow, consider the following step-by-step discussion:

1. Primary energy source: **Coal**

   Coal as primary energy source = 423.1 trillion Btu (total consumption)[57]

   Distribution of coal as a primary energy source shows:

   - Coal as an input to electricity generation: 357.6 trillion Btu[58]
   - Coal as an input to the industrial end use sector: 63.9 trillion Btu[59]
   - Coal as an input to the commercial end use sector: 1.6 trillion Btu[60]

2. Primary energy source: **Nuclear**

   Nuclear as an input to electricity generation = 263 trillion Btu (total consumption and direct distribution to electricity generation)[61]

3. Primary energy source: **Petroleum**

   Petroleum as a primary energy source = 666.5 trillion Btu[62]

   Distribution of petroleum as a primary energy source:

   - Petroleum as an input to electricity generation: 1.7 trillion Btu[63]

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[56] U.S. Energy Information Administration, DOE/EIA-0214(2014). June 2014. *State Energy Consumption Estimates 1960 Through 2012*. Tables C1. Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2012, page 2 and Table C3. Primary Energy Consumption Estimates, page 6. It should be noted that the U.S. Energy Information Administration revises consumption data throughout the year. Revised consumption data can be found at: http://www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_use/total/use_tot_TNcb.html&sid=TN. Accessed August 15, 2014.

[57] *State Energy Consumption Estimates,* Table C1. Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2012, page 2, column heading: Coal.

[58] *State Energy Consumption Estimates*, Table C9. Electric Power Sector Consumption Estimates, 2012, page 12. Column heading: coal.

[59] *State Energy Consumption Estimates*, Table C7. Industrial Sector Energy Consumption Estimates, 2012, page 10. Column heading: coal.

[60] *State Energy Consumption Estimates*, Table C8. Commercial Sector Energy Consumption Estimates, 2012, page 9. Column heading: coal.

[61] *State Energy Consumption Estimates*, Table C9. Electric Power Sector Consumption Estimates, 2012, page 12. Column heading: nuclear electric power.

[62] *State Energy Consumption Estimates*, Table C1. Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2012, page 3, column Petroleum

- Petroleum as an input to the transportation end use sector: 569.8 trillion Btu[64]
- Petroleum as an input to the residential end use sector: 4.8 trillion Btu[65]
- Petroleum as an input to the commercial end use sector: 8.0[66]
- Petroleum as an input to the industrial end use sector: 82.2 trillion Btu[67]

4. For all sources, total energy consumption by primary source is 1,810.8 trillion Btu. (This total includes all sources on the left-hand side of the Sankey diagram.) The following is a discussion of individual primary sources of energy.

Petroleum

The largest primary energy source is petroleum at 666.5 trillion Btu, flowing mainly in a direct route to the transportation sector (about 85 percent of the total consumption).[68] The petroleum category consists of distillate fuel oil, jet fuel, liquefied petroleum gases (LPG), motor gasoline, residual fuel oil, and other.[69]

Consumption in 2012 is consistent with previous years where petroleum was the largest source of energy consumed in Tennessee in both quantity and percentage. Slightly more than 50 percent of the petroleum consumed (Btu) in the transportation sector is motor gasoline.[70] Petroleum flows through an interstate pipeline system and Tennessee is generally an importer of these fuels. As discussed in Chapter 5, the state has few reserves to supplement these imports.

It is important to note that petroleum as a primary source of energy has been declining both in quantity and percentage of total energy consumption at the same time as vehicle miles traveled

[63] *State Energy Consumption Estimates*, Table C9. Electric Power Sector Consumption Estimates, 2012, page 12, Column Petroleum Total.
[64] *State Energy Consumption Estimates*, Table C8. Transportation Sector Energy Consumption Estimates, 2012, page 11. Column: Petroleum Total
[65] *State Energy Consumption Estimates*, Table C5. Residential Sector Energy Consumption Estimates, 2012, page 8. Column Petroleum Total.
[66] *State Energy Consumption Estimates*, Table C6. Commercial Sector Energy Consumption Estimates, 2012, page 9. Column Petroleum Total.
[67] *State Energy Consumption Estimates*, Table C7. Industrial Sector Energy Consumption Estimates, 2012, page 10. Column Petroleum Total.
[68] *State Energy Consumption Estimates*, Table C1. Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2012, page 3, Column “Petroleum.”
[69] Other “includes asphalt and road oil, aviation gasoline, kerosene, lubricants, and the 16 other petroleum products.” See *State Energy Consumption Estimates*, Table C2. Energy Consumption Estimates for Major Energy Sources in Physical Units, 2012, page 4. As noted above, petroleum is also used by the industrial sector (82 trillion Btu).
[70] *State Energy Consumption Estimates*, Table C8. Transportation Sector Energy Consumption Estimates, 2012, page 11, column “Motor Gasoline.”

(VMT) and the number of registered vehicles increased. This is a reflection of efficiency gains and improved fuel economy. Petroleum peaked in quantity of total primary energy source consumed in 2006.[71] VMT in Tennessee totaled 71.129 billion in 2012 compared to 70.745 billion in 2011.[72] Most of the miles were in urban settings (interstate, followed by principal arterial). VMT in the state peaked in 2007 at 71.250 billion. This plateau in VMT is consistent with national trends.

According to Federal Highway Administration statistics, in 2012, Tennessee had 5,392,661 registered vehicles compared to 5,302,335 in 2011. This is the largest number of registered vehicles tracked from 2006 to 2012.[73] The majority of registrations are trucks (2,980,483) followed by automobiles (2,232,584) for 2012.[74]

Although a small portion of the vehicle mix at this point, alternative-fuel vehicles are becoming more economical and popular. EIA reports that there were 21,692 alternative-fuel vehicles in the state in 2011.[75] According to Edmunds, Tennessee ranks in the top 10 states in terms of registered for an electric vehicle rebate program.[76] The *Transportation Energy Data Book*, prepared by Oak Ridge National Laboratory, reports that Tennessee has 1,484 alternative refuel sites (Table 6.8).[77]

Alternative-fuel vehicles combined with new Corporate Average Fuel Economy (CAFE) standards, should result in a further decline in the use of petroleum in the state for the transportation sector.

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[71] Percentage of total primary energy consumed by petroleum as energy source peaked in 1978.

[72] *Tennessee, 2012, Miles and Vehicle Miles of Travel by Functional Class*, Retrieved from: http://www.tdot.state.tn.us/hpms/2012/2012TotalMileageByFuncClass.pdf and Tennessee, 2011, Miles and Vehicle Miles of Travel by Functional Class, Retrieved from: http://www.tdot.state.tn.us/hpms/2011/2011HPMSTotalMilesbyFuncClass.pdf. Accessed August 20, 2014.

[73] State Motor-Vehicle Registrations – 2011 (Revised) and State Motor-Vehicle Registrations – 2012, U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information, Highway Statistics Series, available at: https://www.fhwa.dot.gov/policyinformation/statistics/2012/mv1.cfm and https://www.fhwa.dot.gov/policyinformation/statistics/2011/mv1.cfm. Accessed August 20, 2014.

[74] Trucks can be further disaggregated to: truck tractors, farm trucks, pickups, vans, and sport utilities. Approximately 45% of the "trucks" registered are pickups. See U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy information, Highway Statistics Series, Truck and Truck-Tractor Registrations.

[75] Tennessee State Energy Profile, http://www.eia.gov/state/print.cfm?sid=TN. Accessed August 1, 2014.

[76] Electric Vehicle Rebates, http://www.tn.gov/environment/energy_rebates.shtml. Accessed November 18, 2014.

[77] Stacy C. Davis, Susan W. Diegel, and Robert G. Boundy, *Transportation Energy Data Book, Edition 33*, Oak Ridge National Laboratory, July 2014, retrieved from: http://cta.ornl.gov/data/tedb33/Edition33_Full_Doc.pdf. August 14, 2014.

By 2016, average fuel efficiency will be raised to the equivalent of 35.5 miles per gallon (mpg).[78] Furthermore, federal standards have been finalized that would increase fuel economy to the equivalent of 54.5 mpg by 2025.[79] Combined with previous standards, CAFE is projected to reduce oil consumption by 12 billion barrels.[80]

Further evidence of reduction can be found in EIA's *Annual Energy Outlook 2013 with Projections to 2040.* The reference case in that report projects a decline in consumption of petroleum and other liquids for transportation to approximately 13 million barrels per day by 2030. Further reductions are projected to 2035.[81] Moreover, EIA projects delivered energy consumption by all vehicle types to be the same as 2011 levels. The no-growth projection is the result of declining energy use for light-duty vehicles offset by increases in heavy-duty vehicles, and other transportation modes (air, rail, etc.)[82] This trend will ultimately mean less revenue for the state's gasoline tax which is used primarily to fund transportation infrastructure. In 2012, about 48 percent of state highway fund revenues were derived from the gasoline tax.

Coal

Tennessee relies on coal as its primary fuel source for electricity generation (see the discussion below as well as Chapter 4) and smaller quantities are used by the industrial sector. Energy consumed from coal in 2012 was 423.1 trillion Btu, a decline from 2011. Tennessee's reliance on coal as a primary source of energy consumption peaked in 2000.[83] Despite the fact that the state has coal reserves, Tennessee (primarily through TVA) nonetheless imports coal from nine states: Colorado, Illinois, Indiana, Kentucky, Pennsylvania, Utah, Virginia, West Virginia, and Wyoming (see Figure 3.2). The imports were either bituminous or sub-bituminous.

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[78] *EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks*, U.S. Environmental Protection Agency, Office of Transportation and Air Quality, EPA-420-F-12-051, August 2012.

[79] Ibid.

[80] The White House, Office of Press Secretary, "Obama Administration Finalizes Historic 54.5 MPG Fuel Efficiency Standards," August 28, 2012. Accessed September 5, 2014. http://www.whitehouse.gov/the-press-office/2012/08/28/obama-administration-finalizes-historic-545-mpg-fuel-efficiency-standard.

[81] U.S. Energy Information Administration. *Annual Energy Outlook 2013 with Projections to 2040*. DOE/EIA-0383(2013). April 2013. Figure 14. Consumption of petroleum and other liquids for transportation in three cases, 2005-2040 (million barrels per day), page 27. http://www.eia.gov/forecasts/aeo/pdf/0383%282013%29.pdf. Accessed September 29, 2014.

[82] Ibid. Figure 70. Delivered energy consumption for transportation by mode, 2011 and 2040 (quadrillion Btu). Page 68.

[83] See Table CT2. Primary Energy Consumption Estimates, 1960-2012, Tennessee (Trillion Btu), available at: http://www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_use/total/use_tot_TNcb.html&sid=TN.

Figure 3.2 States Exporting Coal to Tennessee

Table 3.1 Top Four Exporting States – Coal, 2012

Exporting State	Short Tons
Wyoming	8,852,833
Illinois	3,434,046
Kentucky	2,665,993
Colorado	2,493,923

Source: Compiled from EIA-923, Worksheet Page 5, "Fuel Receipts and Costs" and Coal Data Browser, http://www.eia.gov/beta/coal/data/browser/

The majority of imported coal in Tennessee in 2012 came from four states: Wyoming, Illinois, Kentucky, and Colorado. Import amounts (in physical, units rather than Btu) from these four states are presented in Table 3.1.[84]

TVA coal imports from Wyoming went to three plants: Allen,[85] Gallatin, and Johnsonville.[86] TVA also imports coal from Colorado and Utah for those three plants.

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[84] U.S. Energy Information Administration, Form EIA-923, *Power Plant Operations Report*, Available at: http://www.eia.gov/electricity/data/eia923/. See Page 5, Fuel Receipts Data. The majority of imports are for the TVA.

[85] TVA will retire Allen and replace the plant with a natural gas facility. Retrieved from: http://www.knoxnews.com/news/state/tva-board-to-vote-on-replacing-memphis-coal-plant_40956529. Accessed September 1, 2014.

Two general factors tend to influence the source and scope of imported coal: cost and sulfur content. Federal air pollution regulations on sulfur emissions necessitate that some users of coal seek out coal with lower sulfur content because of the environmental controls at the plant site.[87] Table 3.2 shows average sulfur content (range) and fuel cost (range) by exporting state for coal used by TVA. Average sulfur content is measured as sulfur content percent by weight to the nearest 0.01 percent; fuel cost is defined as all costs incurred in the purchase and delivery of the fuel to the plant in cents per million Btu (MMBtu) to the nearest 0.1 cent.[88]

Table 3.2. Characteristics of Coal Exported to Tennessee, 2012

Exporting State	Average Sulfur Content (range)	Fuel Cost (range)
Colorado	.36 - .67	136.1 - 575.50
Illinois	2.60 - 5.80	160.0 – 334.4
Indiana	1.47 – 1.53	321.8 – 334.4
Kentucky	0.75 – 3.20	153.0 – 561.4
Pennsylvania	3.0 – 3.01	391.3 – 477.5
Virginia	0.68 – 1.11	291.1 – 313.1
Utah	.40 - .80	257.6 – 292.7
West Virginia	.63 - .90	344.4 – 352.6
Wyoming	.18 - .50	179.4 – 528.0

Source: Compiled from EIA-923. Worksheet Page 5, Fuel Receipts and Costs. http://www.eia.gov/electricity/data/eia923/

Tennessee Eastman Operations in Kingsport (an industrial end user) imports coal from two states: Kentucky and Virginia.[89] Imports occur on a monthly basis and the average sulfur content is .68 – 1.17. Fuel cost is not available.[90] All shipments of coal imported into Tennessee used rail as its primary transportation mode.

[86] TVA idled several units at Johnsonville in 2012 and another 6 units will be retired by 2017. The facility will use fuel oil or natural gas. See http://www.tva.gov/sites/johnsonville.htm. Accessed September 1, 2014.

[87] Air pollution will be discussed in Chapter 6.

[88] *Content and Layout of the Form EIA-923, Electric Power Generation and Fuel Consumption, Stocks, and Receipts Monthly Time Series Data*, U.S. Energy Information Administration, March 2013. Retrieved from: http://www.eia.gov/electricity/data/eia923/. As a point of reference on costs, EIA reports average sales price of coal as $73.51 per short ton. See http://www.eia.gov/state/?sid=TN. Accessed September 5, 2014.

[89] See Figure 3.1, coal to industrial sector.

[90] See Column T, Fuel Cost, Page 5 Fuel Receipts and Costs in EIA923 Schedules 2 3 4 5 2012 Final Release 12.04.2013. Available at: http://www.eia.gov/electricity/data/eia923/. Accessed August 20, 2014.

Natural Gas

The state's third largest source of primary energy consumed is natural gas. Natural gas used in Tennessee goes directly to three end-use sectors: residential, commercial, and industrial. However, a portion also goes towards electricity generation. A total of 281.2 trillion Btu of natural gas were consumed in 2012. The largest end user was the industrial sector at 107.3 trillion Btu. Tennessee's natural gas consumption has generally increased over the past few years in quantities and as a percentage of energy consumption because of the success of fracking which has reduced prices and the desire for cleaner energy sources. Tennessee's 212 natural gas producing wells had a marketed production of 5,825 million cubic feet in 2012.[91] There is an intricate pipeline system across the U.S. to accommodate the flow of natural gas. EIA's portrayal of southeast regional pipeline is presented in Figure 3.3.[92] The largest natural gas transporter in the state is Tennessee Gas Pipeline Company.

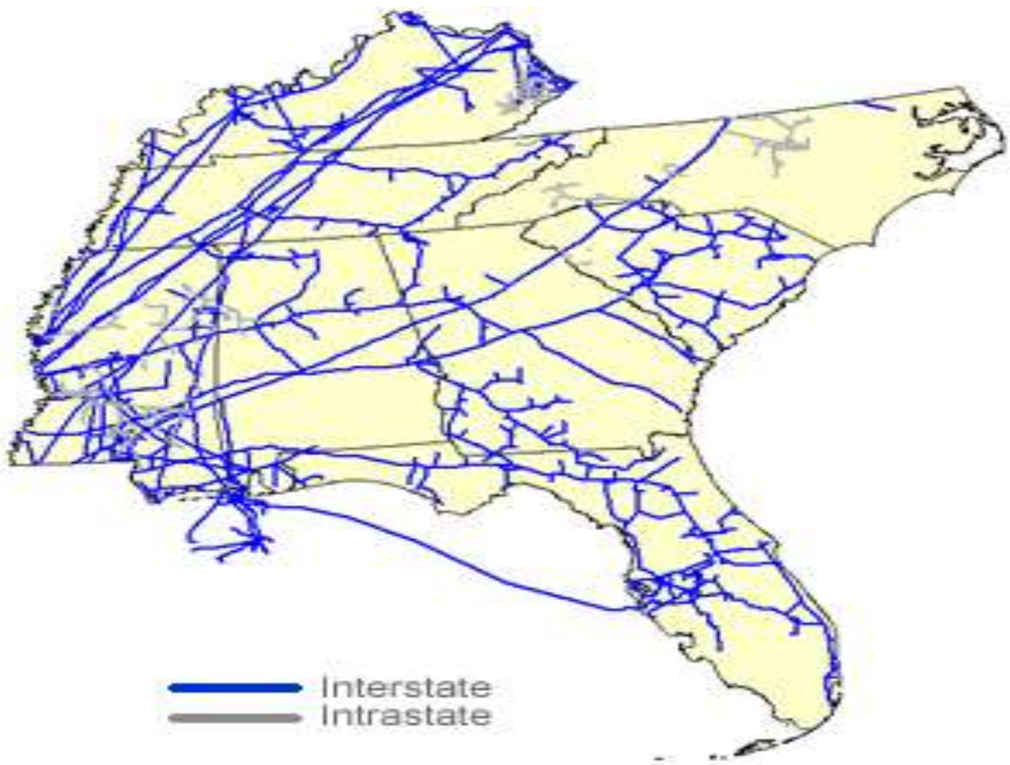

Figure 3.3. Southeast Region Natural Gas Pipeline Network, 2012

Tennessee imported 2,287,081 million cubic feet of natural gas in 2012. The bulk of the imports were from Mississippi.[93] Tennessee also exports natural gas (1,998,527 million cubic feet). The

[91] Tennessee State Energy Profile, http://www.eia.gov/state/?sid=TN. U.S. Energy Information Administration, *Natural Gas Annual 2012*. http://www.eia.gov/naturalgas/annual/. Accessed August 11, 2014.
[92] http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/southeast.html
[93] A more detailed analysis of Tennessee's energy assets is presented in Chapter 5.

natural gas flowed through Tennessee to (primarily) Kentucky.[94] The net interstate movement was 288,554 million cubic feet, highlighting that this is a *pass-through operation*.

Nuclear

TVA operates two nuclear plants in the state: Sequoyah and Watts Bar, both in East Tennessee. Sequoyah Nuclear Plant, 18 miles north of Chattanooga, has two generating units. It has a summer net generating capability of 2,282 megawatts.[95] One generating unit is currently operating at Watts Bar Nuclear Plant, close to Spring City in East Tennessee. Watts Bar has a summer net capability of 1,109 megawatts. A second unit at Watts Bar is under construction--Watts Bar Unit 2 is anticipated to become operational in late 2015.[96] Nuclear energy supports about 11-13 percent of total energy consumption in the state.

Biomass

The primary sources of renewable energy consumed in the state as reported and defined by EIA are biomass and hydro. Like natural gas, biomass is used in electricity generation and by all four end-use sectors. However, the bulk of biomass consumption is through a direct path to the industrial sector, with a smaller amount to transportation. The transportation biomass is fuel ethanol. EIA's biomass category includes wood and waste, fuel ethanol, and losses and co-production from the production of fuel ethanol.[97] Energy consumed from biomass as a percentage of total consumption has increased since 2007.[98]

Hydro

Almost 79 trillion Btu were consumed from hydro electricity generation in Tennessee in 2012. Hydro generally produces only about 2 to 4 percent of the total consumption of energy in Tennessee. TVA operates 30 hydroelectric dams and two *pumped-storage facilities* in Tennessee.[99] These units have varying sized generating units and net dependable capacity. For example, Wilbur Dam has 4 units with a capacity of 11 megawatts, while Fontana has 3 units with 304 megawatts.

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[94] U.S. Energy Information Administration, *Natural Gas Annual 2012*, Table 12. Interstate movements and movements across U.S. borders of natural gas by state, 2012 (million cubic feet). Available at: http://www.eia.gov/naturalgas/annual/pdf/nga12.pdf.

[95] See http://www.tva.gov/sites/sequoyah.htm.

[96] See "May 2, 2014—Quarterly Report: WBN2 on Track for December 2015 Operation, at http://www.tva.gov/power/nuclear/wattsbar_unit2_news_updates.htm#a5-2-14. Accessed September 25, 2014.

[97] See Table C3. Primary Energy Consumption Estimates, 2012, page 6. State Energy Consumption Estimates, 1960 Through 2012, and

[98] See http://www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_use/total/use_tot_TNcb.html&sid=TN.

[99] Personal communication with Tennessee Valley Authority. September 2014.

The remaining renewable fuel sources are solar, wind, and geothermal. The amount of electricity generation from hydro shows some modest fluctuation, while solar, wind, and geothermal are increasing on an annual basis.

Tennessee consumed 1,810.8 trillion Btu of energy in 2012 from primary fuel sources using the approach developed by LLNL (see Figure 3.1 above). Petroleum is the largest primary energy source, followed by coal then natural gas (all fossil fuels). In addition, Tennessee imported electricity for a total energy flow of 1906.1 trillion Btu. Imports are calculated and the equations and data sources are presented below as well as calculations for energy lost in the generation, transmission, and distribution.

Electricity Generation

Primary energy sources can go directly to end-use sectors (e.g., transportation) or to electricity generation. In 2012, a total of 760.1 trillion Btu of electricity were generated in state and 95.3 trillion Btu were imported.[100] Following through the energy flow description, here we use for illustrative purposes residential consumption. Total net energy consumed is 201.9 trillion Btu.[101] Of the residential energy consumed, 135.6 trillion Btu is from electricity generation. The other primary sources are:

- natural gas 54.6 Btu
- petroleum 4.8 Btu
- biomass 6.4 Btu
- geothermal 0.2 Btu
- solar 0.2 trillion Btu.[102]

Figure 3.4 shows Tennessee's 2012 total energy consumption by end-users.

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[100] *State Energy Consumption Estimates,* Table C9. Electric Power Section Consumption Estimates, 2012, page 12. Column heading: Total for 760.1 trillion Btu. The 95.3 trillion net electricity imports is calculated as: net interstate flow of electricity plus net imports of electricity into the United States Million kilowatthours * 3.412 (heat content of electricity, thousand Btu/kWh). We acknowledge and appreciate the assistance of EIA in this calculation. The 233.5 trillion Btu shown in Figure 3.1 is electricity total consumption (i.e., sold) minus net electricity imports. The 526.6 Trillion Btu (light gray) loss is total energy consumed by the electric power sector minus Tennessee generated electricity. Raw data files are available at: http://www.eia.gov/state/seds/seds-data-fuel.cfm?sid=US; accessed August 1, 2014. Codes and Descriptions for the raw data are available at the bottom of the website page.

[101] *State Energy Consumption Estimates*, Table C5. Residential Sector Energy Consumption Estimates, 2012, page 8. Column net energy.

[102] *State Energy Consumption* Estimates, Table C5. Residential Sector Energy Consumption Estimates, 2012, page 8. Columns Natural Gas; Petroleum Total; Biomass (wood), Geothermal, and Solar/PV.

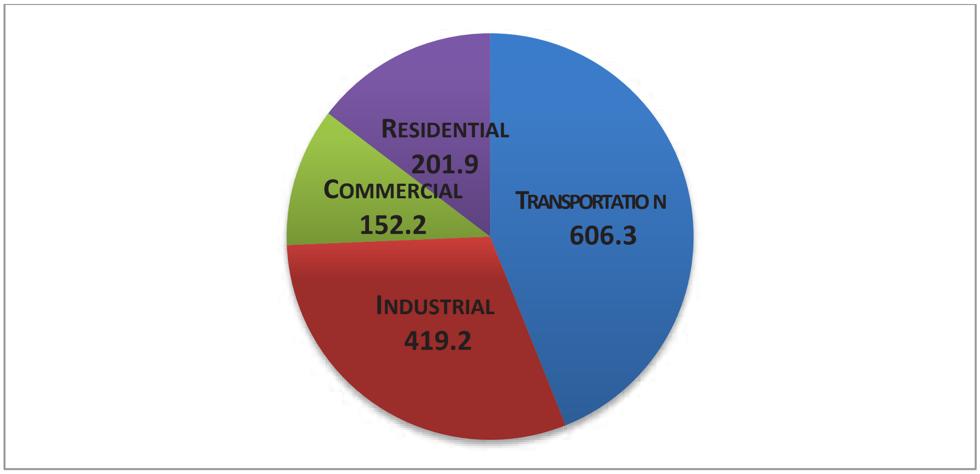

Figure 3.4. Estimated Tennessee *Net Energy* Use by Sector (trillion Btu), 2012[103]

The final point regarding the Sankey diagram in Figure 3.1 pertains to **the inefficiency of the energy generation and consumption process**. These measures are presented as rejected energy (losses) and energy services. Based on research conducted at LLNL, total rejected energy (losses) for Tennessee is 1,181.5 trillion Btu; energy services are 725.7 trillion Btu. End-use efficiencies by each sector included in Figure 3.1 are estimated at:

- 65 percent for residential sector,[104]
- 70 percent for the commercial sector,
- 80 percent for industrial sector, and
- 25 percent for the transportation sector. [105]

The transportation sector demonstrates the lowest efficiency with losses of 75 percent. The industrial sector shows a much higher level of efficiency, but there is still a 20 percent loss.

Per Capita Energy Consumption and Comparison with Bordering States

Energy use by (1) primary energy source and (2) end-user are important metrics that help characterize a state's energy sector. These data reveal the relative reliance on different energy sources and how different consumer groups share in energy consumption. Here we express data in per capita terms to facilitate comparisons across states. Table 3.4 shows per capita net energy consumption by sector for Tennessee.

[103] See *State Energy Consumption Estimates,* Table C5. Residential Sector Energy Consumption Estimates; Table C6. Commercial Sector Energy Consumption Estimates; Table C7. Industrial Sector Energy Consumption Estimates, and Table C8.Transportation Sector Energy Consumption Estimates, Column heading: net energy; pages 8-11.
[104] Calculated as 201.9 trillion Btu times 65 percent as energy services (i.e., energy used).
[105] See *Estimated State-Level Energy Flows.*

Table 3.4. Tennessee Per Capita Net Energy Consumption, 2012

Sector	Per Capita Net Energy Consumption (Million Btu)
Residential	31.58
Commercial	23.78
Industrial	65.50
Transportation	97.73

Figure 3.5 reports data for Arkansas, Missouri, Kentucky, Virginia, North Carolina, Georgia, Alabama, and Mississippi. Tennessee falls in the middle of its bordering states in per capita net energy consumption in the industrial end use sector: Alabama, Arkansas, Kentucky, and Mississippi are higher in per capita net energy consumption than Tennessee. Georgia, Missouri, North Carolina, and Virginia are lower than Tennessee in per capita net energy consumption in the industrial sector.

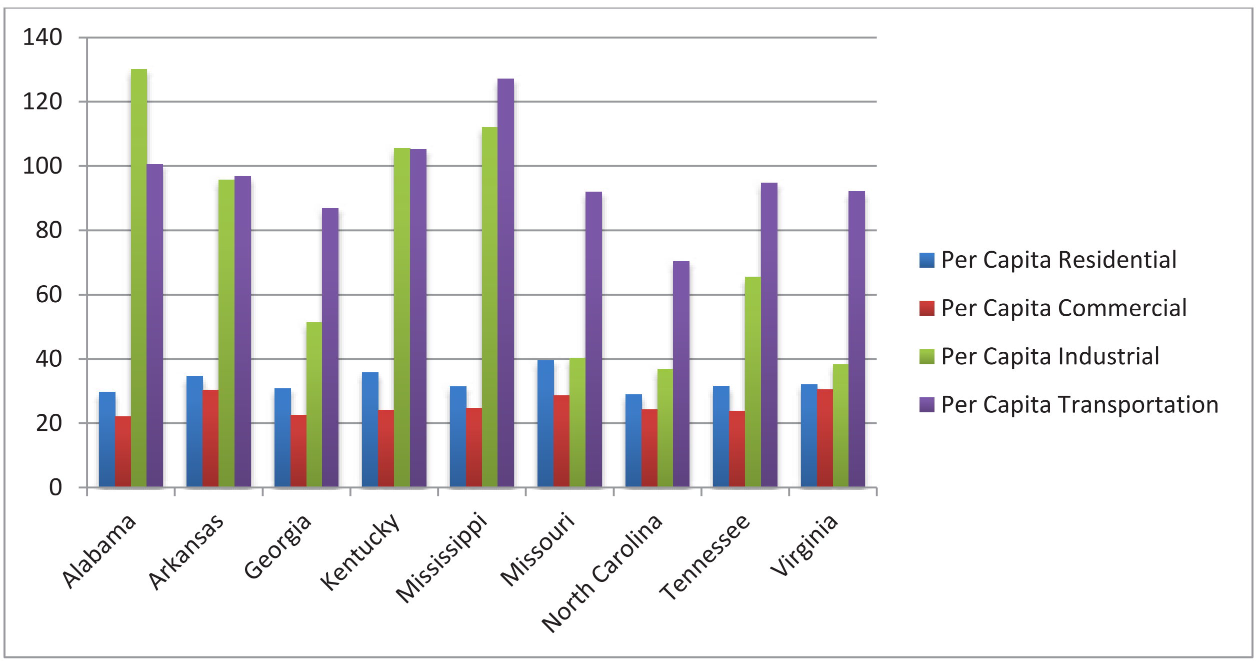

Figure 3.5 Net Energy Use Consumption Per Capita, Tennessee and Bordering States (Million Btu), 2012

Tennessee's residential consumption per capita is similar to consumption in other states in the region. Per capita consumption in the transportation sector is the highest of most sectors in the majority of states.

CHAPTER 4. ELECTRICITY GENERATION AND RETAIL SALES

By Jean Peretz, Howard H. Baker Jr. Center for Public Policy

Key Points

An **overview of *electricity generation* in Tennessee** with a focus on the electric power sector and retail sales of electricity is provided. The electric power sector can be an electric utility, combined heat and power plants (CHPs) of private businesses, and/or independent power producers. Electricity is sold primarily to three end-use sectors: residential, commercial, and industrial, and is measured in kilowatt hours. Data collected by the U.S. Energy Information Administration (EIA) are used unless otherwise noted.

Key findings include:

- Total generation of electricity in Tennessee in 2012 was 77,724 thousand megawatt hours.
- Of the total generation, TVA and the Army Corps of Engineers were the primary generators.
- There are commercial heat and power plants across the state, both in the commercial and industrial sectors.
- Coal is the primary fuel type for electricity generation.[106]
- Natural gas is the primary fuel type for CHPs at commercial sites, while coal is used at CHPs at industrial facilities.
- Retail sales of electricity in 2012 totaled 96,381 thousand megawatt hours.
- The majority of electricity was sold to the residential sector.
- Tennessee's residential electricity usage (kilowatt hour per capita) is second only to Alabama when considering bordering states.

Introduction

Here we focus on electricity generation, a secondary form of energy produced from primary energy sources like coal. Also considered are retail sales of electricity. The electric power sector can be an electric utility, e.g., TVA, or combined heat and power (CHPs) plants either at commercial or industrial sites.[107] TVA sells and transmits electricity to local retailers (e.g., distributors) as well as a number of *directly served* business users who receive electricity directly from TVA. CHPs, on the

[106] Here we use the term "fuel type" rather than primary source of energy to match the EIA data categories.
[107] It is feasible, of course, that households could be off the grid as well.

other hand, almost exclusively use the electricity they generate for their own facilities. Electricity is measured in physical units, generally kilowatt hours, and by heat content.[108] Electricity goes to three end-use sectors: residential, commercial, and industrial. A very small portion (less than 1 percent) goes to the transportation sector, e.g., plug-in electric automobiles.

The data sources for the amounts of electricity generated and retail sales of electricity presented in this chapter are from two surveys that EIA administers.[109] Form EIA-861 is the annual electric power industry report, and Form EIA-923 is power plant operations.

Generators of Electricity

Based on EIA classifications, generators fall into the following categories:
(1) electric generators, electric utilities;
(2) independent power producers (IPPs); and
(3) combined heat and power, industrial or commercial (CHPs).[110]

Electric utilities are public utilities whose purpose is to generate electricity (e.g., TVA). Independent power producers are not part of a public utility. Instead they own or operate facilities to generate electricity for sale to utilities. Combined heat and power facilities are designed to produce heat and electricity. CHP is sometimes referred to as co-generation; however, EIA points out that not all CHPs meet the legal definition of co-generation as set out in the Public Utility Regulatory Policies Act.

Form EIA-923, power plant operations, collects information on the electric power plants, independent power producers, and combined heat and power (CHP) plants. Data gathered include electric power generation and fuel consumption, boiler fuel data, and stocks data, among other things.[111] It should be pointed out that to be included in the mandatory reporting effort by EIA two criteria must be met: generator capacity at a single site must be *1 megawatt* or greater and "where

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[108] The conversion factor is 3,412 Btu per kilowatthour.
[109] Form EIA-860 detailed data is often referenced in this series of data collection efforts by EIA. Form 860 collects generator data and environmental controls at each facility. Accessed August 4, 2014. Available at: http://www.eia.gov/electricity/data/eia860/. Form EIA-906 and -920 were predecessors to EIA-923. See http://www.eia.gov/electricity/data/eia923/eia906u.html. Accessed August 4, 2014. Although the raw data files were used in this analysis, summary data can be found in U.S. Energy Information Administration, *Electric Power Annual 2012*, December 2013.
[110] IPPs and CHPs are described in the "explanation" column in Table 4.1.
[111] See http://www.eia.gov/electricity/data/eia923/. Accessed August 21, 2014.

the generator(s), or the facility in which the generator(s) resides, is connected to the local or regional electric power grid and has the ability to draw power from the grid or deliver power to the grid."[112] The same qualifiers apply on completing survey forms EIA-860 and EIA-861. Raw data from Form-923 was the primary reference for the data presented below.[113]

Table 4.1 describes the sector number, sector name, and explanation for the data included. See the third column for IPPs and CHP descriptions that fit within the categories set out above. The NAICS codes for each sector name will be presented below. The codes are important when considering commercial and industrial CHPs.

[112] U.S. Energy Information Administration, Form EIA-923 Power Plant Operations Report Instructions, Accessed August 4, 2014. Available at: http://www.eia.gov/survey/form/eia_923/proposed/2013/instructions.pdf
[113] Form EIA-923 detailed data. Accessed August 4, 2014. Available at http://www.eia.gov/electricity/data/eia923/.

Table 4.1 Description of Electricity Sector Names, 2012

Sector Number	Sector Name	Explanation
1	Electric Utility	Traditional regulated electric utilities.
2	NAICS-22 Non-Cogen	Independent power producers which are not cogenerators.
3	NAICS-22 Cogen	Independent power producers which are cogenerators, but whose primary business purpose is the sale of electricity to the public.
4	Commercial NAICS Non-Cogen	Commercial non-cogeneration facilities that produce electric power, are connected to the grid, and can sell power to the public.
5	Commercial NAICS Cogen	Commercial cogeneration facilities that produce electric power, are connected to the grid, and can sell power to the public.
6	Industrial NAICS Non-Cogen	Industrial non-cogeneration facilities that produce electric power, are connected to the grid, and can sell power to the public.
7	Industrial NAICS Cogen	Industrial cogeneration facilities that produce electric power, are connected to the grid, and can sell power to the public.

Source: Content and Layout of the Form EIA-923, Table Layout Worksheet. http://www.eia.gov/electricity/data/eia923/. Accessed August 23, 2014.

Quantities of Electricity Generated in 2012

Total generation of electricity in Tennessee in 2012 was 77,724 thousand megawatt hours.[114] Of this total, the majority was generated by the "electric generators, electric utilities," which includes TVA and the Army Corps of Engineers, Nashville Division.[115] Smaller amounts were generated from independent power producers, 114,318 megawatt hours; and combined heat and power, industrial and commercial, 2,548,433 megawatt hours. Industrial CHPs include Tennessee Eastman Operations; commercial includes Vanderbilt University and Gaylord Entertainment (Opryland, USA)

[114] Per capita numbers are presented below.
[115] NAICS code 22, utilities, electric power generation.

as seen in Table 4.2.[116] Comparison numbers for the United States and the eight bordering states are shown in Table 4.3.

Table 4.2. Producers and Megawatt Hours of Electricity Generation, 2012

Type of Producer	Megawatt Hours	Percentage
Electric Utilities	74,897,122	96.36
Independent Power Producers	114,318	.15
Combined Heat and Power, Commercial Power	164,391	.21
Combined Heat and Power, Industrial Power	2,548,433	3.49
TOTAL	**77,724,264**	**100**

Table 4.3. Total Generation, 2012

	Thousand Megawatt hours
United States	4,047,765
Alabama	152,879
Arkansas	65,006
Georgia	122,306
Kentucky	89,950
Mississippi	54,584
Missouri	91,804
North Carolina	116,682
Tennessee	77,724
Virginia	70,739

[116] See also Table 5. Electric power industry generation by primary energy source, 1990-2012, and Table Retail sales, revenue, and average retail price by sector, 1990-2012, Accessed August 4, 2014. Available at: http://199.36.140.204/electricity/state/tennessee/index.cfm.

Sources of Fuel for Electricity Generation

Electric Utilities

The electric utility sector (TVA and the U.S. Army Corps of Engineers) uses several fuel sources. TVA's predominant reliance is on coal and nuclear.[117] The U.S. Army Corps of Engineers operates several hydro facilities in Middle Tennessee and generates exclusively from hydro. Table 4.4 indicates the fuel type and net generation in megawatt hours.

Table 4.4. Electric Utility Generation by Fuel Type, 2012

Fuel Type[118]	Type of Producer	Generation Megawatt Hours	Percentage
Coal	Tennessee Valley Authority	34,249,091	45.73
Hydroelectric Conventional	Tennessee Valley Authority	6,331,659	
	U.S. Corps of Engineers Nashville Division	1,340,863	
Subtotal Hydro		*7,672,522*	*10.24*
Natural Gas	Tennessee Valley Authority	7,892,107	10.54
Nuclear	Tennessee Valley Authority	25,102,101	33.52
Petroleum	Tennessee Valley Authority	144,240	.19
Pumped Storage	Tennessee Valley Authority	-162,939	-.22
TOTAL		**74,897,122**	**100**

Source: Table 5. Electric Power Industry Generation by Primary Energy Source. Accessed August 20, 2014. http://www.eia.gov/electricity/data/state/ . See also Form 923.

Raccoon Mountain

Some forms of electricity generation, like solar and wind, are not capable of providing consistent baseload energy supply. Varying periods of high and low energy demand require methods to store very large amounts of energy at a point in time, regardless of the source of electricity. By far, the most common method of bulk energy storage is *pumped hydroelectric storage* (PHS), accounting for over 99% of bulk energy storage worldwide. PHS uses excess electricity in off-demand periods to pump water to a high-elevation reservoir. Energy is then stored in the gravitational potential of the water until peak demand requires the water to be released downstream, powering electric turbines as it flows. After conversion losses and evaporation losses on the surface of the reservoir, a state-of-the art system can normally attain 80% efficiency.

In 1978, TVA completed the largest rockfill dam it has ever built at Raccoon Mountain in Marion County, just west of Chattanooga. The Raccoon Mountain Pumped Storage Plant pumps water from Nickajack Lake to a reservoir built at the top of Raccoon Mountain. When high electricity demand necessitates increased production, water is directed through an underground tunnel back into Nickajack Lake, driving generators in the underground power plant along the way. The facility uses four generators with a net capacity of 1,652 megawatts.

Sources: D. Rastler, *Electricity Energy Storage Technology Options, A White Paper Primer on Applications, Cost, and Benefits,* Palo Alto, CA: Electric Power Research Institute, December 2010. Accessed September 15, 2014. http://www.epri.com/abstracts/pages/productabstract.aspx?ProductID=000000000001020676; Chi-Jen Yang, *Pumped Hydroelectric Storage,* Durham, North Carolina: Center on Global Change, Duke University. No date. Accessed September 15, 2014. http://people.duke.edu/~cy42/PHS.pdf. Raccoon Mountain Pumped-Storage Plant. Accessed September 15, 2014. http://www.tva.gov/sites/raccoonmt.htm.

Army Corps of Engineers on the Cumberland

In addition to TVA, the US Army Corps of Engineers operates a number of hydro facilities in the state of Tennessee. With the exception of a small strip along the western border, Corps projects in the state are under the direction of the Great Lakes and Ohio River Division, with the main district office in Nashville. The Corps' hydroelectric operations are limited to the Cumberland River Basin in Middle Tennessee. They manage four major flood control reservoirs for the Cumberland River: Center Hill Lake in Smithville on the Caney Fork River, Dale Hollow Reservoir on the Obey River, located on the Kentucky border, Percy Priest Lake on the Stones River, 10 miles east of Nashville, and Lake Cumberland in Russell County, KY. Cordell Hull Dam on the Cumberland River near Carthage is also operated by the Army Corps. Combined, the four Tennessee dams have a capacity of 317 MW.

Sources: U.S. Army Corps of Engineers, Nashville District. http://www.lrn.usace.army.mil/About.aspx. and http://www.lrn.usace.army.mil/Locations/Dams/CenterHillDam.aspx. Accessed September 30, 2014.

Independent Power Producers

EIA reports three independent power producers (IPPs) by plant names and operator names.[120] Table 4.5 shows these along with a fourth, listed as "state-fuel level increment" which is a sum of solar installations across the state; individual installations are not identified. The other IPPs are Invenergy and WM Renewable Energy LLC. In total, IPPs generate 114,318 megawatt hours of electricity. It should be noted that the IPPs are generating electricity from renewable fuel types.

Table 4.5. Electricity Generated by Independent Power Producers, 2012

Fuel Type	Plant Name	Operator Name	Net Generation Megawatt Hours	Percentage
Solar[119]	state-fuel level increment	state-fuel level increment	10,069	8.9
Wind	Buffalo Mountain Energy Center	Invenergy Services LLC	47,492	41.5
Landfill Gas	Chestnut Ridge Gas Recovery	WM Renewable Energy LLC	25,152	
	West Camden	WM Renewable Energy LLC	31,605	
Subtotal Landfill Gas			*56,757*	49.6
TOTAL			**114,318**	**100**

[119] EIA 923 does not specifically name solar operations in the data file. However, when looking at excel worksheet page 6 (plant frame) three solar installations are identified: Volkswagen Solar System, West Tennessee Solar Farm, and Chattanooga Metropolitan Airport. In all likelihood, the Volkswagen and West Tennessee Solar Farm are the sources for the solar numbers presented in the table. The sector name is NAICS-22, non-cogen, with an explanation of "independent power producers which are not combined heat and power plants." The Chattanooga airport is classified as "commercial NAICS non-cogen," described as "commercial non-combined heat and power plant facilities that produce electric power, are connected to the grid, and can sell power to the public." See Table 4.1.

[120] "Operator names" is analogous to owner. For example, WM owns the Chestnut Ridge solid waste landfill.

Waste Management

Waste Management Inc. (WM) is North America's largest provider of integrated waste management solutions. WM operates the largest network of recycling and solid and hazardous waste landfill facilities in the country, including five disposal management facilities in Tennessee. The company offers renewable energy services as well, recovering naturally occurring landfill gas to generate electricity through WM Renewable Energy LLC. Two solid waste landfills are the plant sites for landfill gases. The Chestnut Ridge facility is in Heiskell, Knox County; West Camden is located in Camden, in Benton County.

Buffalo Mountain Energy Center

Invenergy is one of the largest renewable power generation and storage companies in North America, operating more than 8,000 utility-scale renewable and natural-gas facilities. In 2004, Invenergy's Buffalo Mountain Wind Energy Center began commercial operation in Oliver Springs, Tennessee, on the border of Anderson and Roane Counties. Buffalo Mountain's 15 turbines have a nominal power output of 27 megawatts.

Combined Heat and Power, Commercial Plants

Universities and one large hotel chain are included in the CHP, commercial plant category in Table 4.6 below. As with the IPPs, there is one plant name listed as "state-fuel level increment." As with the IPPs, the fuel type is solar for this designation.

Table 4.6. CHPs, Commercial Plant, 2012

Fuel Type	Plant Name	Operator Name	Net Generation Megawatt Hour	Percentage by Fuel Type
Coal	Vanderbilt University Power Plant	Vanderbilt[121] University	20,234[122]	12
Natural Gas	Vanderbilt University Power Plant	Vanderbilt University	47,305	
	University of Tennessee Steam Plant	University of Tennessee	33,851	
	Opryland USA[123]	Gaylord Entertainment Co	18,690	
	MTSU Power Co-Gen Plant	Middle Tennessee State University	39,097	
Subtotal Natural Gas			*141,943*	*86*
Petroleum	MTSU Power Co-Gen Plant	Middle Tennessee State University	100	-
Solar	State-Fuel Level Increment	State-Fuel Level Increment	2,114	1
TOTAL			**164,391**	**100**

Combined Heat and Power, Industrial Plants

The last category of electricity generators included in Form 923 is CHPs, industrial plants.[124] Eight fuel types are used by the five organizations as shown in Table 4.7.

All plant operators are associated with the manufacturing industry, NAICS 31 through 33. Cargill is in the animal food manufacturing sector (NAICS 311). Bowater/Resolute Forest and Packaging Corporation are pulp mills (NAICS code 322). Brookfield is associated with iron and steel mills (Alcoa plants, NAICS 33, see below). Finally, Eastman Chemical (NAICS 325) is petrochemical manufacturing. The IPP and CHP generation numbers are small in comparison with the electric utility industry, but they are likely to grow in the future and become a larger share of the state's electricity generation portfolio.

[121] The NAICS code for educational institutions is 61 (elementary and secondary schools).
[122] The source of coal for Vanderbilt University could not be determined from EIA Form-923 or EPA coal browser. http://www.eia.gov/beta/coal/data/browser/#/shipments/plant/036315/?freq=A&pin=. Accessed August 14, 2014. In all likelihood the amounts fall below the reporting threshold.
[123] The NAICS code for Gaylord/Opryland is 72 (hotels).
[124] They could either be classified as sector number 6 or 7 industrial NAICS non-cogen or industrial NAICS cogen, see Table 4.1 above.

Table 4.7 Combined Heat and Power, Industrial, 2012

Fuel Type	Plant Name	Operator Name	Net Generation Megawatt Hour	Percentage by Fuel type
Coal	Tennessee Eastman Operations	Eastman Chemical Co-TN Ops	1,118,718[125]	
	Bowater Newsprint Calhoun Operation	Resolute Forest Products	12,149[126]	
	Cargill Corn Wet Milling Plant	Cargill Inc	18,204[127]	
	Packaging Corp of America	Packaging Corp of America	914	
Subtotal Coal			*1,149,985*	*45*
Hydroelectric conventional	Calderwood	Brookfield Renewable Power	483,708	
	Chilhowee	Brookfield Renewable Power	139,430	
Subtotal Hydro			*623,138*	*24*
Natural Gas	Cargill Corn Wet Milling Plant	Cargill Inc	6,859	
	Packaging Corp of America	Packaging Corp of America	26,259	
	Tennessee Eastman Operations	Eastman Chemical Co-TN Ops	7,991	
Subtotal Natural Gas			*41,109*	*2*
Other Gases	Tennessee Eastman Operations	Eastman Chemical Co-TN Ops	13,485	1
Other Biomass (sludge waste)	Tennessee Eastman Operations	Eastman Chemical Co-TN Ops	5,449	-
Other	Tennessee Eastman Operations	Eastman Chemical Co-TN Ops	550	-
Petroleum (waste oil)	Packaging Corp of America	Packaging Corp of America	140	-
Wood and Wood derived fuel	Packaging Corp of America	Packaging Corp of America	377,770	

[125] Sources of imports to the Eastman facility are provided in the Chapter 3.
[126] Sources of coal were not available in EIA Form-923 or coal browser for Bowater, presumably because the quantities fall below the threshold level for data collection.
[127] Sources of coal were not available in EIA Form-923 or coal browser for Cargill, presumably because the quantities fall below the threshold level for data collection.

Table 4.7 Combined Heat and Power, Industrial, 2012

Fuel Type	Plant Name	Operator Name	Net Generation Megawatt Hour	Percentage by Fuel type
	Bowater Newsprint Calhoun Operation	Resolute Forest Products	336,807	
Subtotal wood			*714,577*	*28*
TOTAL			**2,548,433**	**100**

Brookfield Smoky Mountain Hydropower

From 1919-1957, Alcoa constructed four hydroelectric facilities along the Little Tennessee and Cheoah Rivers in Tennessee and North Carolina, including the Calderwood and Chilhowee facilities in Blount and Monroe counties. The purpose of these facilities was to provide power for the aluminum smelter and rolling mill in Alcoa, TN. For over 75 years, these dams were operated by the Tallassee Power Company (later known as Tapoco). In 2009, the aluminum operations in Alcoa were shut down, and Alcoa no longer required the hydro facilities in the Smoky Mountain foothills.

In 2012, Brookfield Renewable Energy Partners – a publicly traded, renewable energy platform based in Quebec – purchased these facilities to expand its North American operations. Two Tennessee facilities – Calderwood and Chilhowee – had an installed capacity of 192 megawatt hours.

Sources: "Alcoa Finalizes Sale of Tapoco Hydroelectric Project to Brookfield Renewable Energy Partners," November 2012. Accessed September 19, 2014. http://www.alcoa.com/global/en/news/news_detail.asp?pageID=20121115006710en&newsYear=2012 . "Tennessee Operations." Brookfield Renewable Energy Partners L.P. Accessed September 19, 2014. http://brookfieldrenewable.com/content/tennessee-36153.html.

Tennessee Eastman Company, Kingsport – CHP Award

Tennessee Eastman Chemical, one of the largest chemical manufacturing facilities in the U.S., was recently recognized by the Environmental Protection Agency. Eastman won EPA's ENERGY STAR Combined Heat and Power (CHP) Award for the company's CHP system. The system achieves operating efficiency of 78 percent, higher than conventional production of electricity. Seventeen boilers produce steam to help meet space heating and cooling needs of 550 buildings and drive several steam turbine generators with a combined design output of 200 MW. The predominantly coal-fired system requires approximately 14 percent less fuel than grid-supplied electricity and conventional system production. The system also reduces air emissions.

See Combined Heat and Power Partnership, U.S. Environmental Protection Agency, http://epa.gov/chp/. Press Release September 30, 2014. See also http://epa.gov/chp/partnership/current_winners.html#one. Accessed October 3, 2014.

The following Table 4.8 presents ***total* electricity generation by fuel type in Tennessee and the U.S.** Figure 4.1 is confined to electricity generation in Tennessee. Note that this includes all electricity generators, i.e., utilities, IPPs, etc. As can be seen, coal has the largest share, followed by nuclear for Tennessee. There is a somewhat different picture when considering U.S. electricity generation by fuel type. Although coal is still the largest percentage (37 percent), natural gas is higher and nuclear is lower than Tennessee.

Table 4.8. Total Electricity Generation by Fuel Type, Tennessee and United States, 2012

Fuel Type	Tennessee Megawatt Hours	Percentage TN	U.S. Megawatt Hours	Percentage U.S.
Coal	35,419,309	46	1,514,042,945	37
Hydroelectric conventional	8,295,660	11	276,240,223	7
Natural Gas	8,750,160	10	1,225,894,175	30
Nuclear	25,102,101	32	769,331,249	19
Other	550	-	13,787,067	-
Other Biomass	62,206	-	19,823,037	-
Other Gases	13,486	-	11,897,585	-
Petroleum	144,480	-	23,189,541	1
Pumped Storage	-162,939	-	-4,950,496	-
Solar	12,183	-	4,326,675	-
Wind	47,492	-	140,821,703	3
Wood and Wood Derived Fuels	714,577	1	37,799,129	1
Geothermal			15,562,426	-
TOTAL	**77,724,264**	**100**	**4,047,765,259**	**100**

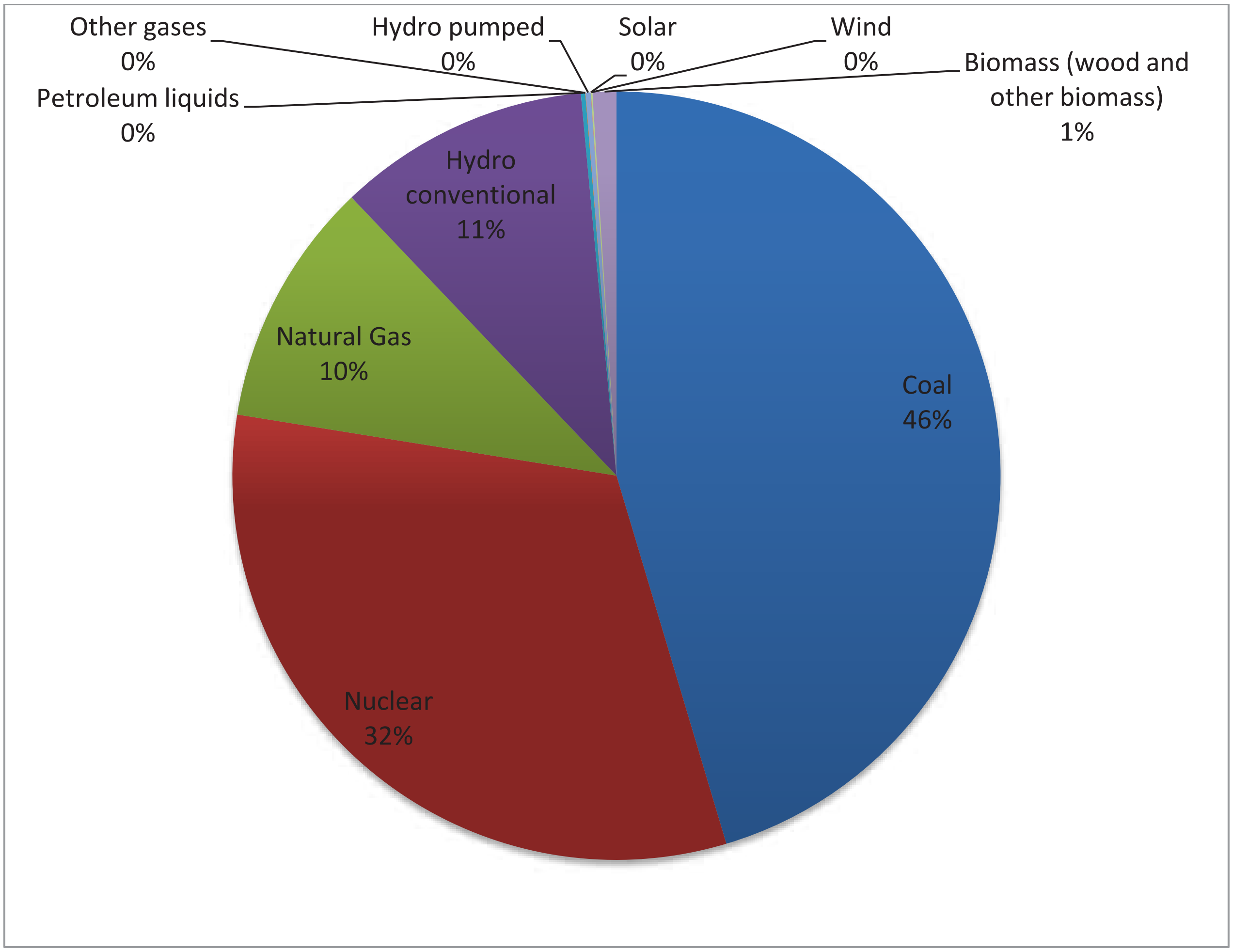

Figure 4.1. Electricity Generation by Fuel Type Tennessee - 2012 Data (Percentage of Megawatt hours)

Retail Sales of Electricity in Tennessee

Tennessee also imports electricity because the state's retail sales are higher than in-state generation. In 2012, Tennessee's retail sales totaled 96,381,472 megawatt hours.[128] While the residential sector is a modest consumer of net energy (reference back to Figure 3.4), it is the primary consumer of electricity in Tennessee at 41 percent as seen in Figure 4.2 and Table 4.9. That is not the case in the U.S. as shown in Table 4.9. Here the U.S. residential sector accounts for 34 percent of retail sales. The U.S. commercial sector has the largest percentage of retail sales at 38 percent, and industrial is at 28 percent.

[128] U.S. Energy Information Administration, *Electric Power Annual 2012*, December 2013. See Table 2.8 Retail Sales of Electricity to Ultimate Customers by End-Use Sector. http://www.eia.gov/electricity/annual/. Accessed August 14, 2014.

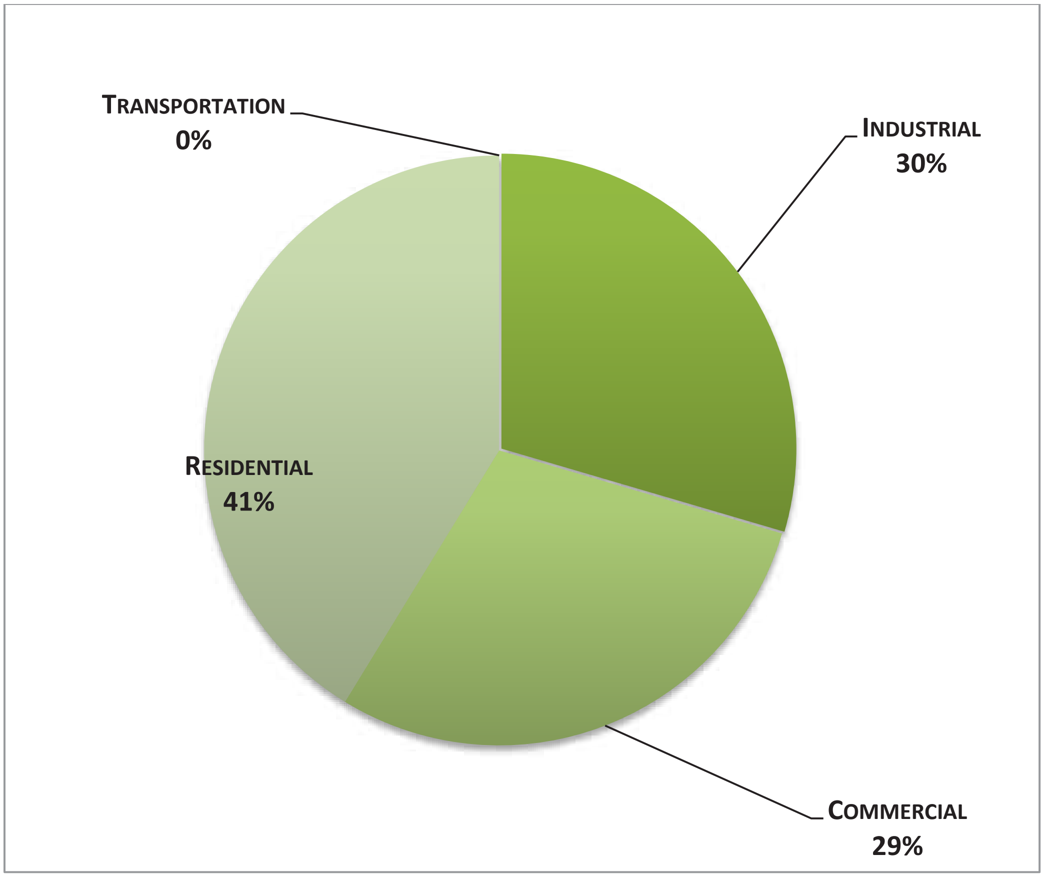

Figure 4.2 Estimated Tennessee Electricity Sales by Sector (percentage), 2012

Table 4.9. Retail Sales by Sector, 2012

Sector[129]	Tennessee Megawatt hours	Percentage	U.S.	Percentage
Residential	39,753,631	41	1,451,210,975	34
Commercial	28,150,141	29	1,580,855,626	38
Industrial	28,475,956	30	1,163,622,568	28
Transportation	1,744		13,250,716	
TOTAL	**96,381,472**	**100**		**100**

While the percentages of electricity supplied to Tennessee's industrial and commercial sectors are similar, there are very large differences between these sectors in terms of the *number of customers* served by each sector. Table 4.10 shows the distribution of customers for the respective consumer groups.

[129] Sector can also be considered end-user, although EIA uses the specific term "sector" when reporting data on electricity sales.

Table 4.10. Retail Sales of Electricity by Customer Count in Tennessee, 2012

Sector	Customer Count	Percentage
Residential	2,721,099	85
Commercial	466,513	15
Industrial	1,957	-
TOTAL	3,189,569	100

Source: "Electric power sales, revenue, and energy efficiency Form EIA-861 detailed data files. Accessed August 14, 2014. http://www.eia.gov/electricity/data/eia861/

The distributors serving the largest number of industries included in the EIA database are listed below. [130] The top five are:

City of Memphis (Memphis Light Gas & Water, MLGW)	326 industries
NES (Nashville Electric Service)	239 "
Kingsport Power Company American Electric Power[131]	165 "
City of Chattanooga (Electric Power Board)	116 "
Middle Tennessee Electric Membership Cooperation	113 "

Commercial organizations are more disbursed, as one might expect. Recall that commercial includes sectors such as education, health care, retail, and warehouses, among others. In general there will not be the concentration that is observed in industrial or residential. For example, MLGW and NES serve the largest number but at only 18 percent. This is intuitive since commercial includes, as noted above, educational facilities. Finally, the distributors serving the population centers of the state include both municipal utilities (MLGW, NES, City of Chattanooga Electric Power Board or EPB and Knoxville Utilities Board), and a cooperative (Middle Tennessee Electric Membership Cooperative).

[130] For reference, three of the distributors are municipally owned, one is a cooperative and the fifth is investor-owned.

[131] Appalachian Power, owned by American Electric Power, an investor-owned electric utility, covers about 47,000 customers in upper East Tennessee (Kingsport area). The service area is 297 square miles, with electric sales of 2,316,980 megawatt hours. The majority of the customers are residential (slightly more than 41,000) with average cost per kilowatt hour for residential service of 8.37 cents. Some well-known customers include the City of Kingsport, Eastman Chemical, and Domtar Corporation (Weyerhaeuser).

Residential Sector

Tennessee ranks high in its residential electricity use per capita and has for several years. Tennessee is in a region characterized by hot/humid summers and mild winters.[132] Tennessee also enjoys electricity prices lower than the national average. In 2012, Tennessee's *per capita* consumption of electricity was 6,157 kilowatt hours. This far exceeds the U.S. per capita consumption of electricity at 4,378 kWh. In fact, Tennessee ranks second to Alabama in terms of electricity consumption among bordering states. Alabama's per capita electricity usage was 6,353 kWh as shown in Figure 4.3 below.

Electricity costs represent a relatively large share of the household budget in Tennessee. Tennessee's per capita income is below the national average and ranks behind Virginia, Missouri, Georgia, and North Carolina. On the other hand, in terms of kWh per dollar of income, Tennessee ranks behind Mississippi, Arkansas, Alabama, and Kentucky. Lower per unit costs help mitigate the burden from greater energy utilization.

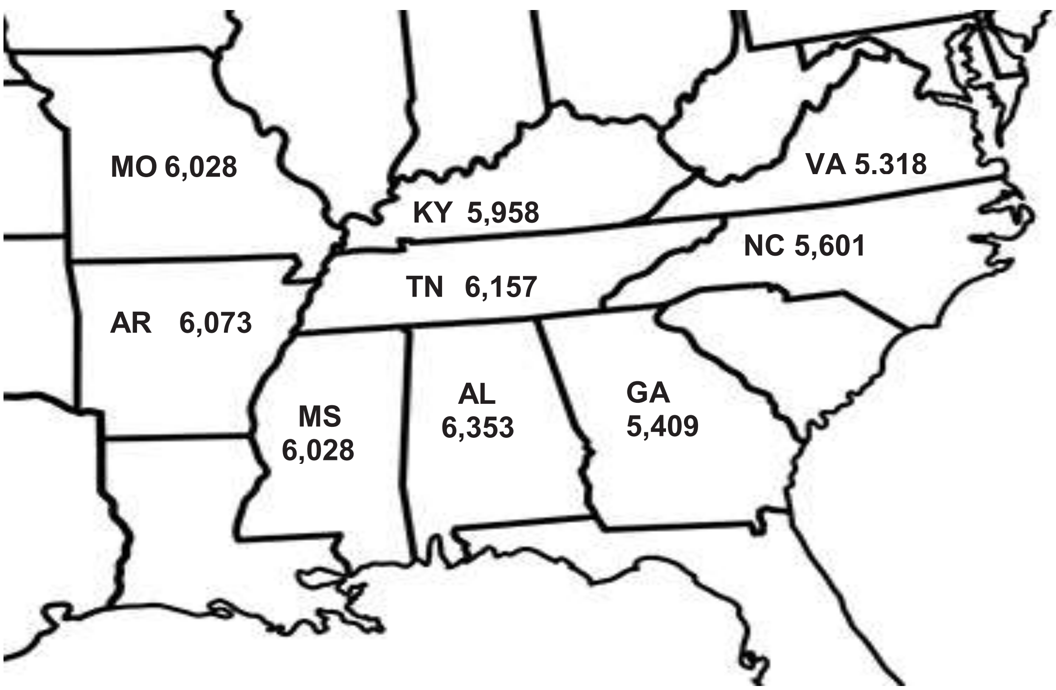

Figure 4.3. Residential Electricity Usage (kilowatt hour per capita), 2012

[132] Climate region designation: Mixed-Humid. Climate regions were created by the Building America program, sponsored by the U.S. Department of Energy's Office of Energy and Efficiency and Renewable Energy (EERE). See Table HC2.10 Structural and Geographic Characteristics of Homes in South Region, Divisions, and States, 2009. http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=characteristics. Accessed September 24, 2014.

A brief review of housing characteristics in Tennessee may shed some light on the high per capita use. Census Bureau data on housing markets in Tennessee show that homeownership rates are higher than the national average, 68.4 percent versus 65.5 percent.[133] The majority of housing units are single-family detached, in urban areas, and have not had energy audits performed on the structures.[134] The state's high residential electricity consumption, coupled with its relatively low per capita personal income, suggests that there may be the need for more aggressive energy efficiency programs targeted to the housing stock.

Housing Units and Fuels Usage

Additional insight for this high ranking may be gleaned from EIA's Residential Energy Consumption Survey (www.eia.gov/consumption/residential/). EIA engages in this data collection effort periodically to gain *detailed* information on household activities. The data presented in Table 4.11 were collected in 2009. However, this is the most comprehensive, up-to-date information available on specific household characters. Data are collected on home heating (e.g., electricity or natural gas); cooling methods (e.g., window air conditioning units); electronics (e.g., televisions); appliances (e.g., refrigerators, freezers, clothes washers); and housing types (single family versus mobile homes). Data are collected by Census Track. The results for the East South Central Census Division are presented by (1) Tennessee and (2) Alabama, Kentucky and Mississippi collectively.

Table 4.11. 2009 Residential Energy Consumption Survey Results—Fuel Use[135]

	Tennessee (in Millions)	Percent	Alabama, Kentucky, Mississippi	Percent	United States	Percent
Housing Units Included in Study	2.4		4.6		113.6	
Fuels Used for any Use:						
Electricity	2.4	100	4.6	100	113.6	100
Natural gas	1.0	42	1.8	42	69.2	61
Propane	0.9	38	2.2	38	48.9	43

[133] "State and County QuickFacts," http://quickfacts.census.gov/qfd/states/47000.html. Accessed September 24, 2014. See Homeowner rate, 2008-2012.

[134] "Table HC2.10 Structural and Geographic Characteristics of Homes in South Region, Divisions, and States, 2009." http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=characteristics. Accessed September 24, 2014.

[135] "Table HC1.10 Fuels Used and End Uses in Homes in South Region, Divisions, and States, 2009." In each category, more than one may apply. See http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=characteristics Accessed September 24, 2014.

Electricity End Uses :						
Space heating	1.8	75	3.2	70	58	51
Air cond.	2.4	100	4.5	98	94	83
Water heating	1.8	75	3.1	67	47.1	41
Cooking	2.2	92	3.6	78	71.2	63
Natural Gas End Uses:						
Space heating	.8	33	1.5	33	57.2	50
Water heating	.6	25	1.4	30	58.4	51
Propane End Use						
Space heating	.2	8	.8	17	8.0	7

Tennessee households tend to use electricity for heating, air conditioning, and water heating and cooking at higher rates than households in Alabama, Kentucky, Mississippi or the U.S. Natural gas is more frequently used in the U.S. for space and water heating than in the Southern states listed above. Propane end use is more common in Alabama, Kentucky, and Mississippi, than in Tennessee or the U.S. as a whole. Clearly, Tennesseans are using electricity for heating and air conditioning. More than one fuel can be used per housing unit, e.g., electricity could be used for cooking and natural gas for space heating. But in general the reliance is on electricity. Upfront costs of appliances may limit household adoption of more modern and efficient appliances.

As noted above, electricity is the primary source for space heating. Central warm-air furnaces, five to nine years old, *without* routine maintenance, used as a source for the majority of square footage, and without a programmable thermostat, dominate in Tennessee. [136] The daytime temperature setting when someone is at home is between 67 to 70 degrees. The temperature setting changes only slightly when no one is at home during the daytime (67 to 69 degrees). Nighttime setting is 67 to 69 degrees.[137]

Programmable thermostats are generally not installed.[138] Electric central air conditioning and heat pumps are used by most households. Units tend to be old and not subject to regular maintenance.

[136] A lack of routine maintenance is observed across three groupings set out above: Percentages for *lack* of maintenance is highest in Tennessee at 67%; Alabama, Kentucky, and Mississippi at 63%; U.S. at 58%. In other words, more than 50% of the residences do not perform routine maintenance on main heating equipment. See "Table HC6.10 Space Heating in U.S. Homes in South Region, Divisions, and States, 2009."

[137] "Table HC6.10 Space Heating in U.S. Homes in South Region, Divisions, and States, 2009."

[138] "Table HC7.10 Air Conditioning in Homes in South Region, Divisions, and States, 2009."

What other activities, e.g., appliance use, contribute to the heavy use? These data may shed light on opportunities for household conservation and efficiency gains.

Appliances - (Stoves, Refrigerators, Dishwashers, Clothes Washers and Dryers)

Many Tennessee housing units use electric stoves, with use evenly split between once a day and a few times each week. Ovens are also used a few times each week. It is interesting to note that "once a day" hot cooked meals occur more frequently in Alabama, Kentucky, and Mississippi as well as in the U.S. than Tennessee. Considering other survey results, it is not surprising that electricity is the most used cooking fuel (88 percent as opposed to 74 percent in Alabama, Kentucky, and Mississippi and 60 percent in the U.S.). The difference is primarily the use of natural gas outside of Tennessee for cooking.

The majority of housing units have one refrigerator with two doors (top freezer) that is five to nine years old and of medium size (15-18 Cubic Feet). Dishwashers are used two to three times a week and are also five to nine years old. It is interesting to note that Tennesseans use their dishwashers more frequently than households in the U.S. and Alabama, Kentucky, and Mississippi. Heating the water helps further explain the residential usage for Tennessee homes.

The most commonly used clothes washer is top loading, five to nine years old, and used for two to four loads each week. Wash cycles are warm, with cold for the rinsing. Electric clothes dryers are not surprisingly five to nine years old, and are used every time clothes are washed.[139] Newer units will demonstrate much higher efficiency than these older units.

There have been significant improvements in the energy demand (in Tennessee's case, electricity) used for common household appliances over the past several years. For example, approximately 60 percent of the energy used for a dishwasher goes to heating the water (whether electric or natural gas). New models significantly reduce the amount of water used per cycle; the same applies to clothes washers. Newer models require less energy and use less water. Finally, clothes dryers are the most energy-intensive appliance in a household. Suggestions for improving the efficiency of

[139] "Table HC3.10 Appliances in Homes in South Region, Divisions, and States, 2009."

dryers include not overloading the dryer and checking the dryer exhaust vent. [140] As with other appliances, new models are generally more energy efficient.

Electronics (Televisions, Computers)

Tennesseans have multiple televisions in their housing units. Ninety-six percent of Tennessee households have between 1 and 4 televisions.[141] The following information pertains to the most-used television. Display size is 21 to 36 inches, with LCD display type, used three to six hours per weekday (33 percent). The three to six hours per weekday is fairly consistent when comparing Tennessee to Alabama, Kentucky, Mississippi and the U.S. The U.S. has a slightly higher percentage usage at 38 versus 33 percent observed in the other groupings.

Weekend use has an even split between (1) three to six hours and (2) more than 10 hours for Tennessee households.[142] The more than 10 hours category shows a *higher use rate* for Tennessee at 29 percent as compared to 17 percent observed for Alabama, Kentucky, Mississippi and the U.S.

Close to 1 million housing units have at least one computer, either a desktop or laptop, which is used one to three hours per day. A higher percentage of households in Alabama, Kentucky, Mississippi and the U.S. own computers. With regard to power management, Tennesseans either turn the computer off when not used or use a sleep or standby mode when not in use.[143] A higher percentage turns off the computer when not in use in the remaining three southern states included here and the U.S.

Taken collectively, these characteristics help explain the high residential electricity use in Tennessee. The data also reveal opportunities for initiatives to promote less energy use through conservation and improved efficiencies associated with newer products.

EIA Surveys Conducted of Commercial and Manufacturing Sectors

Unfortunately, the Commercial Building Energy Consumption Survey does not provide specific information for Tennessee; instead the results are grouped by regions (northeast, midwest, south,

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[140] See http://www.aceee.org/consumer. It should be noted that an ENERGYSTAR rating for clothes dryer does not exist at this time. Accessed October 1, 2014.

[141] The 96 percent is consistent with Alabama, Kentucky, and Mississippi and is higher than the 90% for the United States. See "Table HC4.10 Televisions in Homes in South Region, Divisions, and States, 2009."

[142] "Table HC4.10 Televisions in Homes in South Region, Divisions, and States, 2009."

[143] "Table HC5.10 Computers and Other Electronics in Homes in South Region, Divisions, and States, 2009."

and west). No individual states are listed. The limited data make it difficult to assess energy burdens for businesses in Tennessee.

Manufacturing Energy Consumption Survey

The Manufacturing Energy Consumption Survey data (collected in 2010) are organized by Census regions. Tennessee falls under the South Census Region.[144] Although the data collected captures net demand for electricity for all Southern states, a review can be made of the NAICS codes with the largest percentage of net demand and comparisons with employment numbers in Tennessee. The largest percentages of net demand for electricity in the southern states by NAICS codes are:

NAICS	Description	Percentage
325	Chemicals	31
322	Paper	14
324	Petroleum and Coal Products	9

When examining employment as a proxy for the impact of these four sectors on the Tennessee economy, one can see that these are not the largest sectors in terms of employment. Instead the transportation equipment (NAICS code 336), fabricated metals (NAICS code 332), and food products (NAICS code 311) sectors had the largest number of employees in 2013.[145] However, the chemical sector (NAICS code 325) is significant at 24,200 employees.

Unfortunately, there are no other publicly-available data showing energy use by business consumers. This makes it exceedingly difficult to determine how energy use affects business competitiveness in Tennessee.[146]

Prices of Electricity

Tennessee's electricity rates are below the national average, though they have increased over the past few years. Prices for 2012 were:

[144] States in the South are: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. http://www.eia.gov/tools/glossary/index.cfm?id=C. Accessed September 25, 2014.
[145] Matthew N. Murray and Vickie C. Cunningham, *Tennessee's Manufacturing Sector Before and After the Great Recession*, March 2014. UT Center for Business and Economic Research, Knoxville, TN. http://cber.bus.utk.edu/pubs/mnm134c1.pdf. Table 1: Employment in Tennessee's Manufacturing Sector Changes Markedly, page 5.
[146] Recall that EIA form 861 presents number of industrial customers by distributor.

	Tennessee	U.S. Average
Residential	10.91 cents/kWh	12.84 cents/kWh
Commercial	10.47 cents/kWh	10.51 cents/kWh
Industrial	5.92 cents/kWh	6.76 cents/kWh

Average prices are lower in Tennessee than on average around the country and have been for many years. This helps make the state an attractive location for both households and businesses. Industrial firms often have the flexibility to locate production facilities in any of a number of states, so Tennessee's relatively low rates are especially important in supporting a strong business climate.

CHAPTER 5. NATURAL RESOURCE BASE AND PRODUCTION OF ENERGY

By Jean Peretz, PhD & Charles Sims, PhD, Howard H. Baker Jr. Center for Public Policy

Key Points

This chapter examines **Tennessee's natural resource base from an energy perspective and the potential for energy production** sourced in the state. Specifically, what natural resource capabilities exist in Tennessee to serve as a fuel source for in-state use and potentially for export? Tennessee's natural resource base includes reserves of nonrenewable resources (fossil fuels) as well as favorable environmental conditions for some forms of renewable energy. For example, with 61,075 river and stream miles, Tennessee has an extensive hydropower base. However, based on current resource exploration and extraction technologies, Tennessee is not considered to possess abundant fossil fuel resources. The wider application and development of natural gas fracking technologies may change this outlook in the future.

Key findings include:

- As a percentage of total production, **Tennessee tends to produce more biofuels and coal and less natural gas and crude oil** than the country as a whole.
- The coal currently mined in the state is bituminous coal from eastern Tennessee. There has been a general **declining trend in coal production in the state** (and the region) over the past decade both in terms of gross tonnage mined and number of mines.
- The majority of the 218 gas fields in Tennessee are in Scott, Morgan, and Fentress Counties. **Tennessee ranked among the lowest 10 producing states in marketed natural gas** production in 2012 with 5,825 million cubic feet.
- In 2012, Tennessee's crude oil proved reserves accounted for 0.6 percent of the proven reserves of crude oil in the U.S. Most of the state's oil fields are in Morgan, Scott and Fentress Counties. **Tennessee ranked among the lowest 10 producing states in crude oil** production in 2013 with 309,000 barrels.
- **Tennessee ranks 20th** (out of 37 states) **in acres suitable for switchgrass** (a biofuel feedstock) but **ranks 2nd in average yield.**
- There are additional opportunities to **exploit energy production from solar** in Tennessee.

Fossil Fuels

Coal Reserves

Sizeable lignite[147] coal reserves exist in the Cretaceous and Tertiary deposits of western Tennessee. These deposits are highly variable in thickness which inhibits extensive mining operations. The Tennessee Geological Survey has been working with the U.S. Geological Survey to assess impacts on groundwater resources that might arise should surface mining of those reserves ultimately be developed. The coal currently mined in the state is bituminous coal which occurs in the coalfields of east Tennessee (see Figure 5.1). Bituminous is the most abundant coal in active U.S. mining regions and is primarily used as fuel in steam-electric power generation with substantial quantities also used for heat and power applications in manufacturing to make coke.[148] Its moisture content is usually less than 20 percent and the heat content of bituminous coal consumed in the U.S. averages 13,000 Btu per pound (see Table 5.1). Bituminous coal is characterized by relatively low ash content but may have very high sulfur content. More than half of all available coal resources are bituminous. This type of coal is generally located east of the Mississippi River.

Table 5.1 Coal Types

	Anthracite	Bituminous	Sub-bituminous	Lignite
Heat content (Btu/lb)	13,000-15,000	11,000-15,000	8,500-13,000	4,000-8,300
Moisture	<15%	2-15%	10-45%	30-60%
Ash	10-20%	3-12%	≤ 10%	10-50%
Sulfur	0.6-0.8%	0.7-4%	< 2%	0.4-1%

Source: Indiana Center for Coal Technology Research, Purdue University

The measurement of coal reserves vary based on technological and economic factors. There are a few different ways of measuring the size of coal reserves in Tennessee:[149]

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[147] Lignite (brown coal) is the lowest rank of coal and used almost exclusively as fuel for steam-electric power generation. Its moisture content can reach as high as 60 percent and the heat content of lignite consumed in the U.S. averages 6,000 Btu per pound. Lignite has very high ash content but may have lower sulfur content than bituminous coal (see Table 5.1).

[148] Coke is a solid carbonaceous residue derived from low-ash, low-sulfur bituminous coal from which the volatile constituents are driven off by baking in an oven at temperatures as high as 2,000 degrees Fahrenheit so that the fixed carbon and residual ash are fused together. Coke is used as a fuel and as a reducing agent in smelting iron ore in a blast furnace. Coke from coal is grey, hard, and porous and has a heating value of 24.8 million Btu per ton.

[149] Reserve estimates collected from EIA's *Annual Coal Report, 2012.* All reserve expressions exclude silt, culm, refuse bank, slurry dam, and dredge operations. For more information see *Appendix A: Review of U.S. Coal Resource and Reserve Data Criteria and Terminology* in U.S. Coal Reserves: A Review and Update.

Figure 5.1. Location of Tennessee Bituminous Coalfields

Demonstrated reserve base (technologically minable) is a collective term for the sum of coal in both measured and indicated resource categories of reliability, representing 100 percent of the in-place coal in those categories as of a certain date that meet specific minability criteria (capable of being mined). This category includes 1) beds of bituminous coal and anthracite 28 or more inches thick, 2) beds of sub-bituminous coal 60 or more inches thick that can occur at depths of up to 1,000 feet, and 3) beds of lignite 60 or more inches thick that can be surface mined. This category also includes thinner and/or deeper beds that presently are being mined or for which there is evidence that they could be mined commercially at a given time. The demonstrated reserve base represents that portion of the identified coal resource from which reserves are calculated. Tennessee's 2012 demonstrated reserve base was 753 million short tons down slightly from 754 million short tons in 2011. This amounts to 0.16 percent of the demonstrated reserve base in the U.S. Underground mining methods would be required for 500 million short tons with the remaining 253 million short tons requiring surface mining methods.

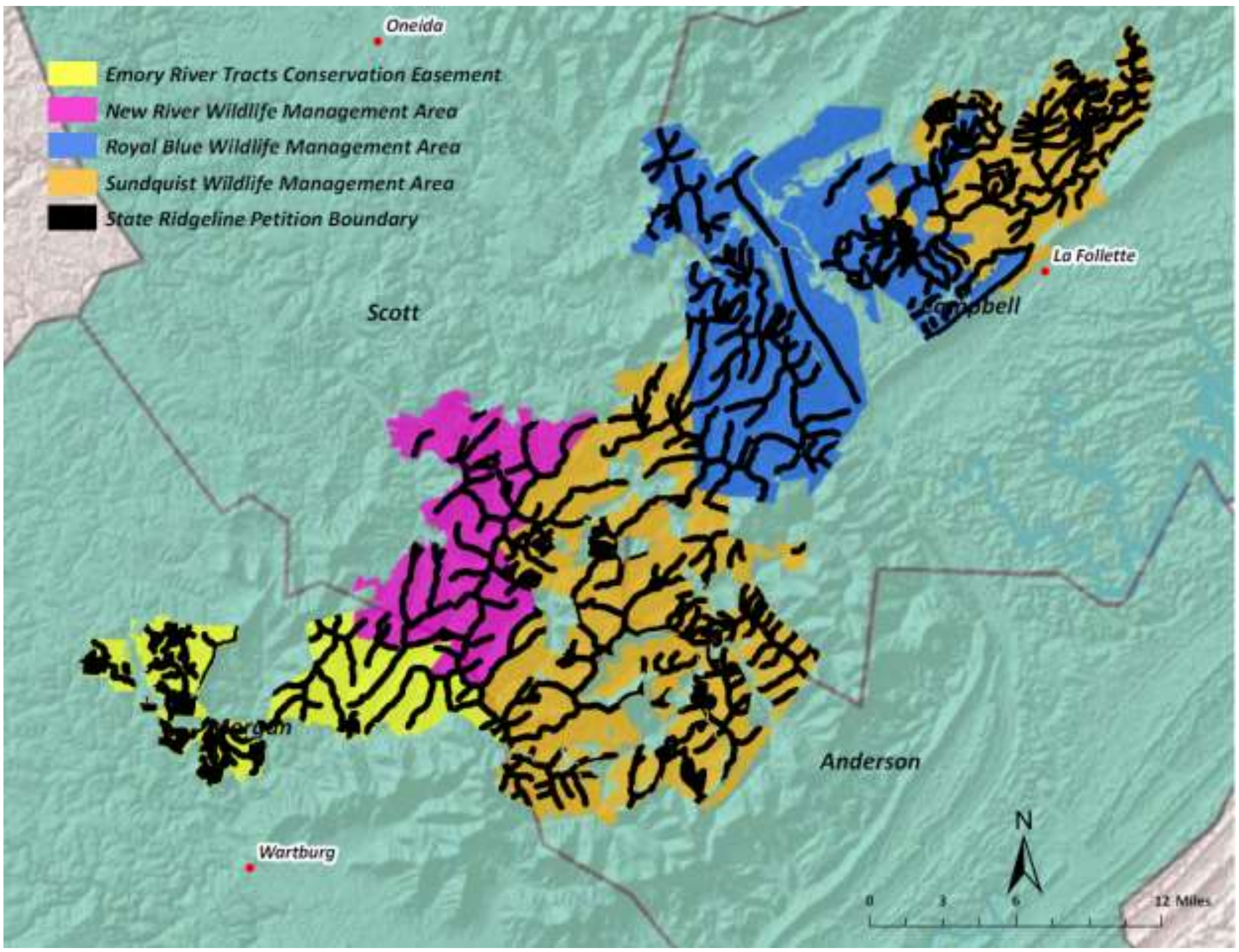
Estimated recoverable reserves include coal in the demonstrated reserve base considered recoverable after excluding coal estimated to be unavailable due to land use restrictions or currently economically unattractive for mining after applying assumed mining recovery rates. Tennessee's 2012 recoverable reserves were 445 million short tons down slightly from 446 million short tons in 2011. This amounts to 0.17 percent of the demonstrated reserve base in the U.S. Underground mining methods would be required for 274 million short tons with the remaining 171 million short tons requiring surface mining methods.

Recoverable coal reserves at producing mines represent the quantity (measured resources plus indicated resources) of coal that can be mined from existing coal reserves. Tennessee's 2012 recoverable reserves at producing mines were 4 million short tons. This represents a 50 percent decrease from 2011. This sharp decline was due to a 43 percent drop in the number of reporting mines in Tennessee from 2011 to 2012.

Average Recovery Percentage is the percentage of coal that can be recovered from known coal reserves at reporting mines using a weighted average for all mines in the reported geographic area. The average recovery percentage in the U.S. is 78 percent. This number tends to go up over time reflecting improvements in mining technology. By comparison the average recovery percentage in Tennessee is 57.27 percent and has been falling over the past few years. This continual decline in the average recovery percentage suggests that those mines remaining in Tennessee have relatively less abundant reserves compared to other mines in the geographic region.

Lands Unsuitable for Mining petition

In 2010, the state of Tennessee submitted a Lands Unsuitable for Mining petition for the North Cumberland Wildlife Management Area (NCWMA) and Emory River Tracts Conservation Easement. These areas are in the northeastern part of the state on the Northern Cumberland Plateau in Anderson, Campbell, Morgan, and Scott Counties. The petition designates areas within 600 feet of all ridge lines lying within the NCWA (67,000 acres total) as unsuitable for surface coal mining in support of a conservation project called "Connecting the Cumberlands." In 2013, the Federal Office of Surface Mining Reclamation and Enforcement initiated the process of securing contractual services to develop and finalize a combined Petition Evaluation Document/Environmental Impact Statement



Lands Unsuitable for Mining Petition Boundaries
Source: Office of Surface Mines 2011

Natural Gas Reserves

Proved reserves of natural gas are estimated volumes of hydrocarbon resources that analysis of geologic and engineering data demonstrates with reasonable certainty are recoverable under existing economic and operating conditions. Reserve estimates may change as new discoveries are made, existing fields are more thoroughly appraised, existing reserves are produced, and prices and technologies change. Discoveries include new fields, identification of new reservoirs in previously discovered fields, and extensions, which are additions to reserves that result from additional drilling and exploration in previously discovered reservoirs. Within a given year, extensions are typically the largest percentage of total discoveries. While discoveries of new fields and reservoirs are important indicators of new resources, they generally account for a small portion of overall annual reserve additions.

Natural gas development may be from conventional and unconventional sources. Conventional gas resources have a high permeability and flow rate making them easier to extract. Much of the natural gas development experienced in the last decade has come from unconventional sources such as coal bed methane and shale gas.[150] Estimating proved reserves from these unconventional sources is more difficult. The size of the technically recoverable resource base in the U.S. becomes evident only as producers drill into geologic deposits with oil and gas potential and attempt to produce from them on a commercial basis. As producers find *plays* to be more or less bountiful than expected, resource estimates are adjusted to reflect that information. As time passes and our knowledge of the resource base and future technologies and management practices improves, estimates of the technically recoverable resource base will be refined.

Tennessee experienced an uptick of well drilling activity five to ten years ago when natural gas prices were higher.[151] This activity has dropped off in recent years as natural gas prices have fallen considerably. Natural gas prices are expected to increase slightly in the years ahead as necessary infrastructure is developed to export gas produced from the U.S. This increase in prices may be sufficient to re-initiate drilling activity in the state which would provide a clearer picture of Tennessee's natural gas resources. Obtaining a clear picture of Tennessee's natural gas reserves is further complicated by the fact that the Energy Information Agency (EIA) aggregates Tennessee measures with other states with little drilling activity in order to avoid disclosure of individual

[150] Tight gas and gas hydrates are two other unconventional resources that are not widespread in Tennessee.
[151] *EIA SEDS database: Number of Producing Gas Wells (*http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm*)*

company data. However, this aggregated data does serve as an upper limit on Tennessee's natural gas reserves.

Coal bed methane (CBM) is a gas contained in coal beds that is usually not commercially viable for mining. As shown in Figure 5.2, coalbed methane fields exist in Alabama, Kentucky, and Virginia. According to EIA's *U.S. Crude Oil and Natural Gas Proved Reserves Report,*[152] Tennessee has no proved reserves of coalbed methane as of 2012.

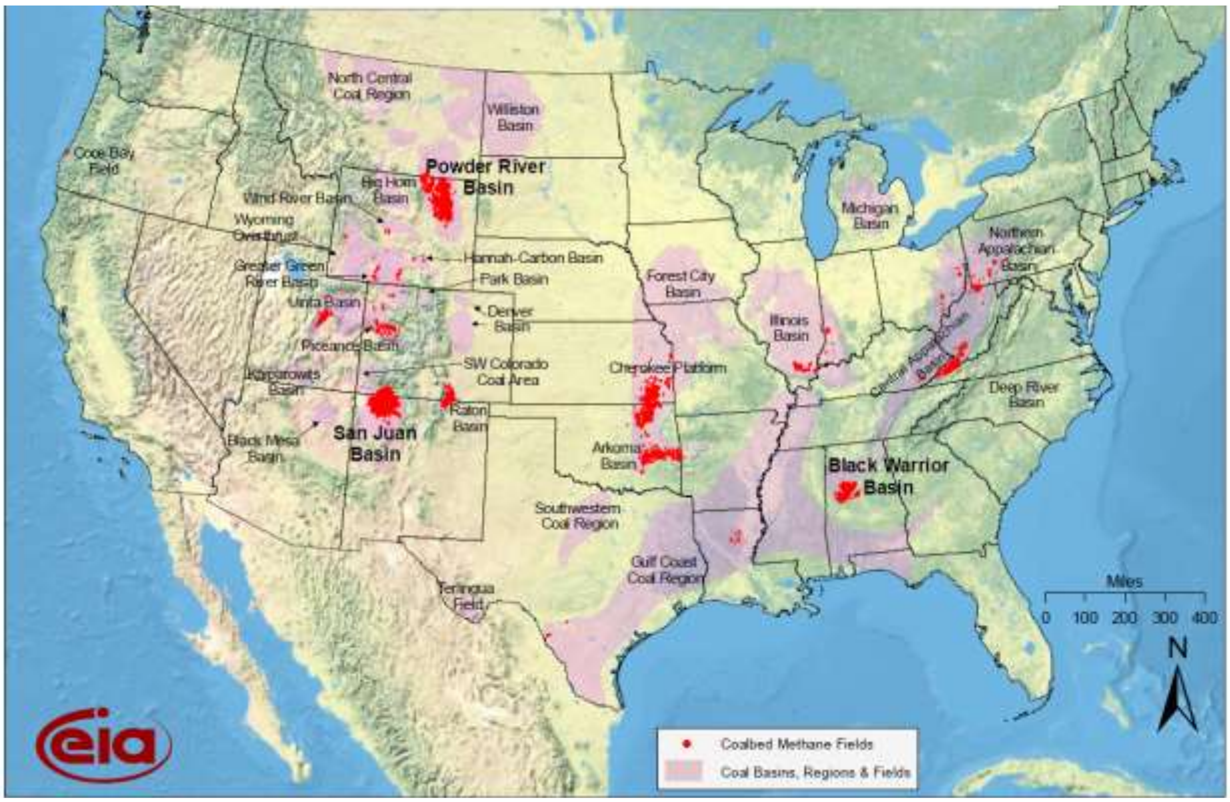


Figure 5.2. Coalbed Methane Fields in the Lower 48 States, 2009
Source: Energy Information Administration based on data from USGS and various published studies

Shale gas is a natural gas produced from shale rock contained in shale formations and extracted by way of horizontal drilling and hydraulic fracturing. According to EIA's *U.S. Crude Oil and Natural Gas Proved Reserves Report,*[153] proved reserves of shale natural gas in the state are less than 535 billion cubic feet.[154] This represents less than 0.4 percent of the proved reserves of shale natural gas in the U.S.

[152] http://www.eia.gov/naturalgas/crudeoilreserves/archive/2012/index.cfm Accessed September 12, 2014.
[153] http://www.eia.gov/naturalgas/crudeoilreserves/archive/2012/index.cfm Accessed September 12, 2014.
[154] This number represents the aggregate of Indiana, Missouri, and Tennessee.

Exploration of the Chattanooga Shale play's potential natural gas resources is under way in the north eastern part of the state (see figure 5.3). The Chattanooga Shale is located at a depth of between 3,000 to 4,000 feet and ranges in thickness from 80 to 200 feet.[155] As you go north into Kentucky, the Chattanooga Shale thickens to over 1,000 feet. The thinness of the Chattanooga Shale means that less water is needed to extract the trapped gas – a low-water shale play. Depending on basin and formation characteristics, 2 million to 4 million gallons of water are generally needed to drill and fracture a horizontal shale gas well.[156] A low-water shale play is potentially attractive to producers due to the lower cost of water and chemicals. Low-water shale plays also lessen the need to store waste water (also called flowback and produced water) that is often forced out of the well during production. This wastewater contains fracturing chemical additives and must be stored onsite in tanks or open pits before disposal. The onsite storage of wastewater has raised concerns over potential impacts to drinking water in a number of states. Preliminary operations in Tennessee have found more success with nitrogen fracking where all the fluid used in hydro-fracking is replaced by nitrogen gas which can fracture rock at high pressure much like water.

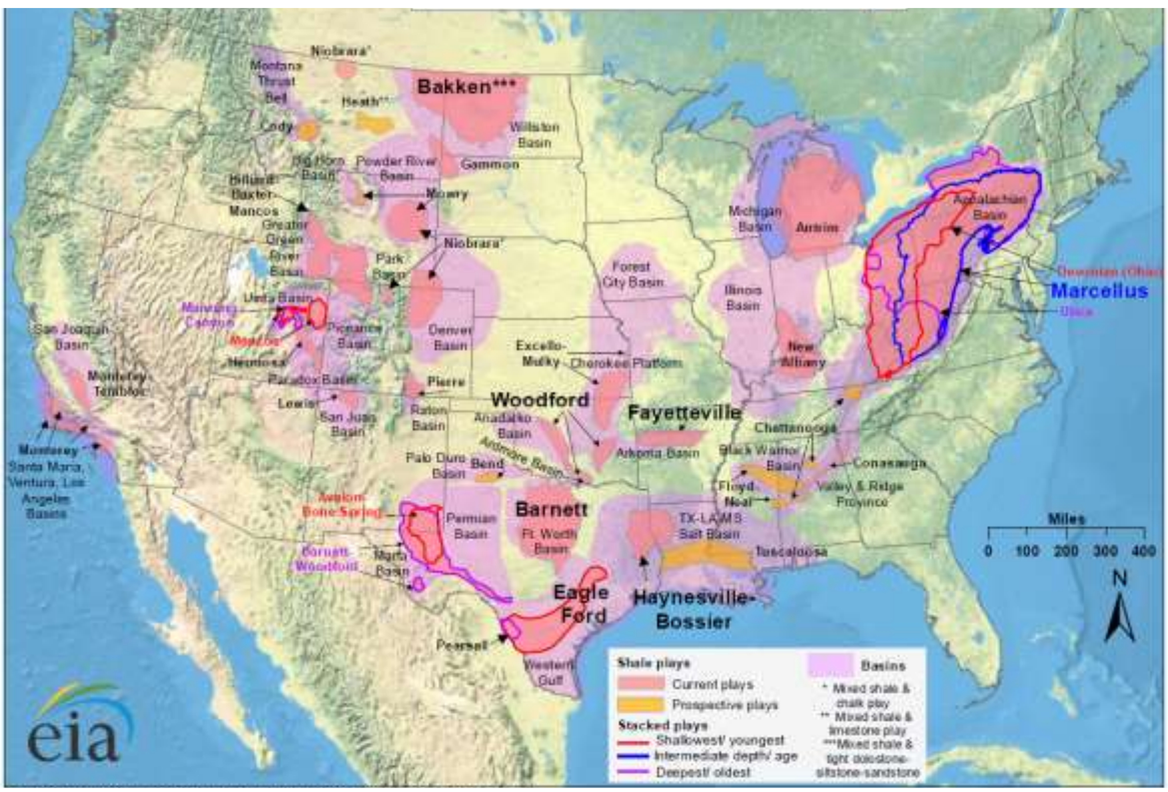


Figure 5.3. Lower 48 States Shale Plays, 2011
Source: Energy Information Administration based on various published studies

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155 http://oilshalegas.com/chattanoogashale.html Accessed September 26, 2014.
156 Groundwater Protection Council, "Modern Shale Gas Development in the United States: A Primer,"

To determine where these reserves may be located we turn to EIA's Oil and Gas Field Code Master List.[157] There are 218 non-associated or associated-dissolved gas fields in Tennessee. Non-associated natural gas is natural gas that is not in contact with significant quantities of crude oil in the reservoir. Associated-dissolved natural gas is natural gas that occurs in crude oil reservoirs either as free gas (associated) or as gas in solution with crude oil (dissolved gas). Natural gas fields are defined as "an area consisting of a single reservoir or multiple reservoirs all grouped on, or related to, the same individual geological structural feature and/or stratigraphic condition. There may be two or more reservoirs in a field which are separated vertically by intervening impervious strata, or laterally by local geologic barriers, or by both." Scott County has the most gas fields followed by Morgan County (see Figure 5.4). However, no new fields in Tennessee have been added to the list since 1984.

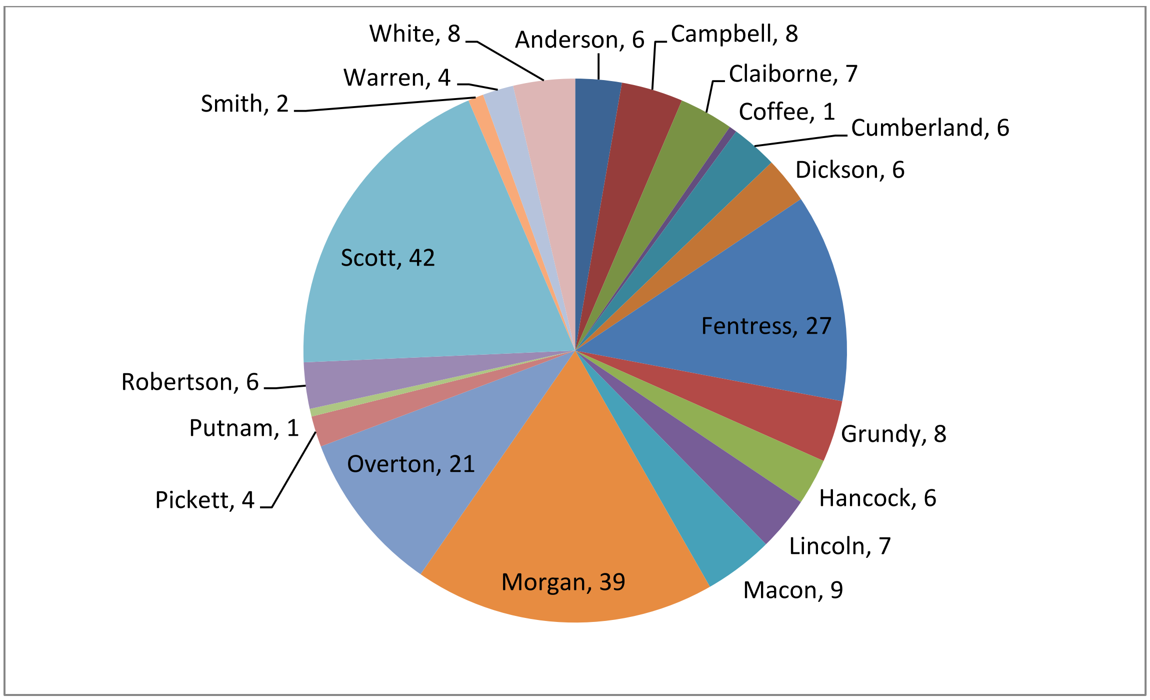

Figure 5.4. Location of Gas Fields in Tennessee
Source: EIA's Oil and Gas Field Code Master List

Crude oil reserves

Proved reserves of crude oil are the estimated quantities (often in millions of barrels[158]) of all liquid crude oil, which geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating

[157] http://www.eia.gov/naturalgas/fieldcode/ Accessed October 12, 2014.
[158] One barrel = 42 U.S. gallons.

conditions. Estimates of proved crude oil reserves do not include the following: (1) oil that may become available from known reservoirs but is reported separately as "indicated additional reserves"; (2) natural gas liquids (including lease condensate); (3) oil, the recovery of which is subject to reasonable doubt because of uncertainty as to geology, reservoir characteristics, or economic factors; (4) oil that may occur in undrilled prospects; and (5) oil that may be recovered from oil shales, coal, gilsonite, and other such sources. It is necessary that production, gathering or transportation facilities be installed or operative for a reservoir to be considered proved.

There were less than 44 million barrels of crude oil proved reserves in Tennessee in 2012.[159] This represents less than 0.6 percent of the proved reserves of crude oil in the U.S. There are 283 oil fields in Tennessee where the oil field definition is similar to the gas field definition previously mentioned.[160] Morgan County had the most oil fields followed by Scott County (see figure 5.5). However, no new fields in Tennessee have been added to the list since 1984.

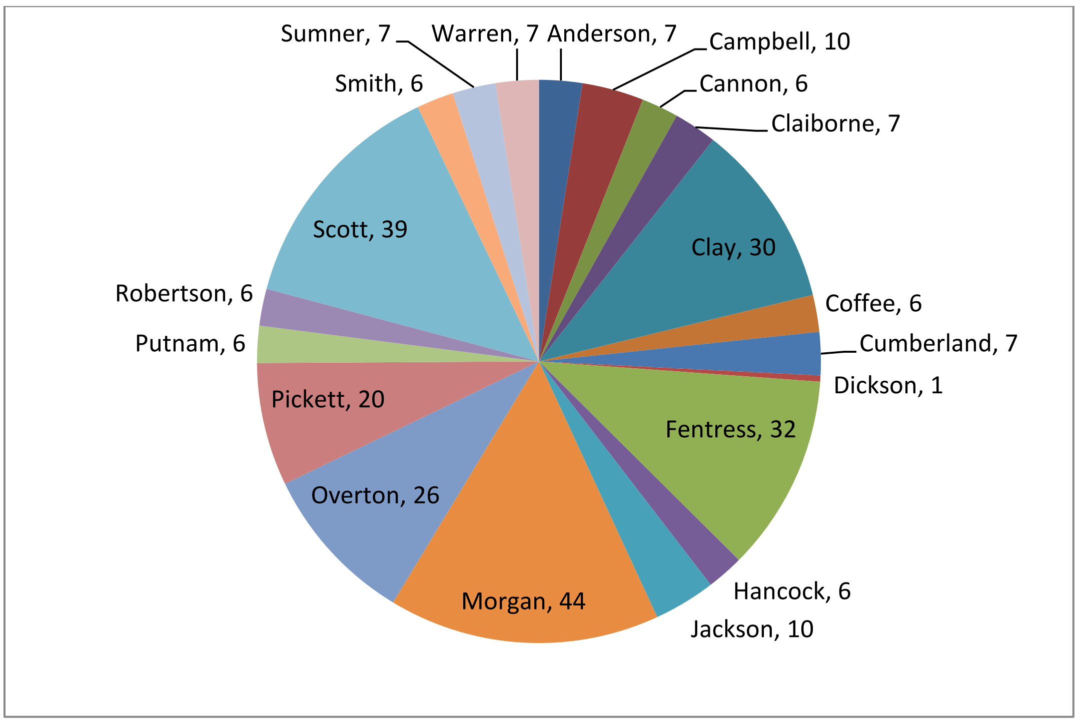

Figure 5.5. Location of Oil Fields in Tennessee
Source: EIA's Oil and Gas Field Code Master List

[159] EIA's U.S. Crude Oil and Natural Gas Proved Reserves Report. This number represents the aggregate of Arizona, Missouri, Nevada, New York, South Dakota, Tennessee, and Virginia.
[160] EIA's Oil and Gas Field Code Master List (http://www.eia.gov/naturalgas/fieldcode/). Accessed October 12, 2014.

Renewables

The National Renewable Energy Laboratory (NREL) of the U.S. Department of Energy (DOE) has primary responsibility for renewable energy and energy efficiency research and development within DOE. It is the primary laboratory for DOE's Office of Energy Efficiency and Renewable Energy. One of NREL's responsibilities is to provide data and develop maps of renewable resources across the U.S. NREL prepares maps on the potential of six renewables: biomass, geothermal, hydrogen, marine and hydrokinetic, solar, and wind.

The maps in Figures 5.6-14 display various renewable resource opportunities within Tennessee. It should be noted that emerging technologies like those alluded to in Chapter 2 could have an influence on the present capabilities. For example, development of a different turbine or blade size for wind power could change this outlook. Regardless this gives a sense of Tennessee's potential to utilize renewables, such as solar, wind and biomass, in the production of primary and secondary energy.

Biomass

EIA defines biomass as "organic non-fossil material of biological origin constituting a renewable energy source." Common examples of biomass include fast growing trees, switchgrass, corn stover (stalk, leaf, husk, and cob) and biomass waste. The biomass feedstocks are used to make biofuels (ethanol, biodiesel) which serve as a fuel source primarily for the transportation and industrial sectors. According to Figure 5.6, there is up to 250-500 thousand tons/year of biomass resources in Tennessee. The majority of these resources are in West Tennessee. Researchers at ORNL have found that Tennessee has more than 4.5 million acres of cropland with the right soil and climate conditions for switchgrass and short rotation woody crops. Suitable cropland is located in all of Tennessee's 95 counties.[161] Figures 5.7 and 5.8 show the number of acres of cropland suitable for switchgrass and the average yields in each state. Tennessee ranks 20th in the number of acres of suitable cropland, among the 37 states included in the study. However, Tennessee ranks 2nd (behind Kentucky) in average switchgrass yield. While states in the northern plains (Minnesota, Wisconsin, Iowa) have more acres of cropland suitable for switchgrass, it is unclear whether sufficient yields can be routinely achieved in these areas due to year-to-year climatic variation.

[161] Graham, R. and M. E. Wash. 2001. *A National Assessment of Promising Areas for Switch grass, Hybrid Poplar, or Willow Energy Crop Production*. ORNL-6944, Bioenergy Feedstock Development Program, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN

Sufficient yields have been routinely achieved in southern states (Alabama, Tennessee, Virginia) where climatic variability is less.

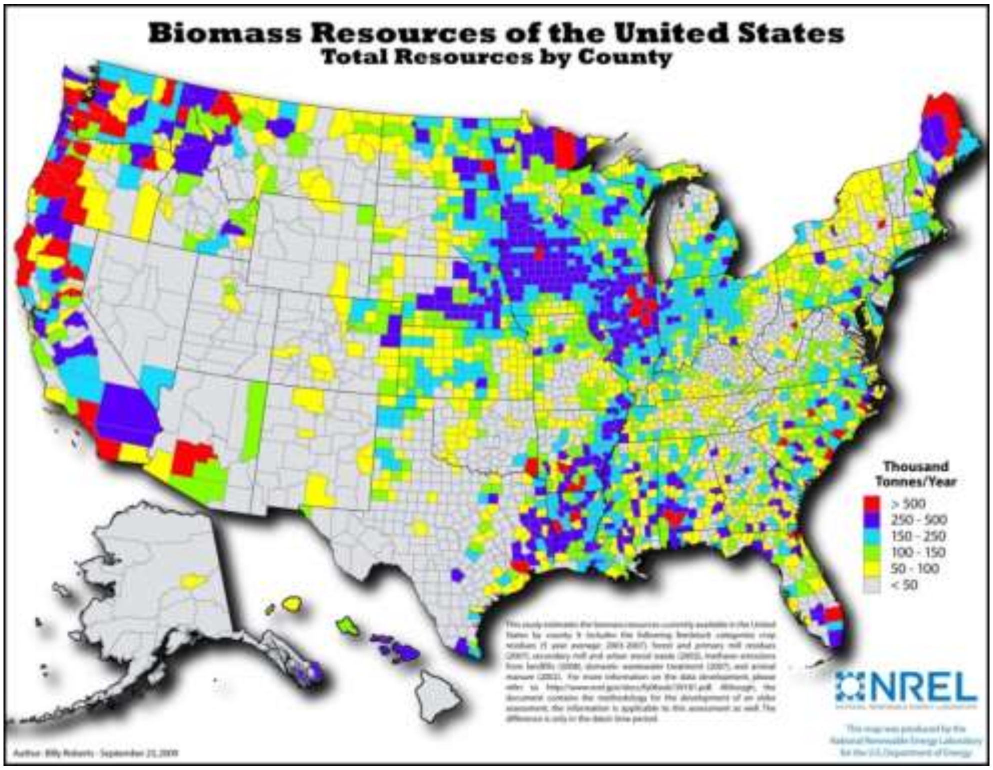

Figure 5.6. Biomass Resources of the U.S. by County

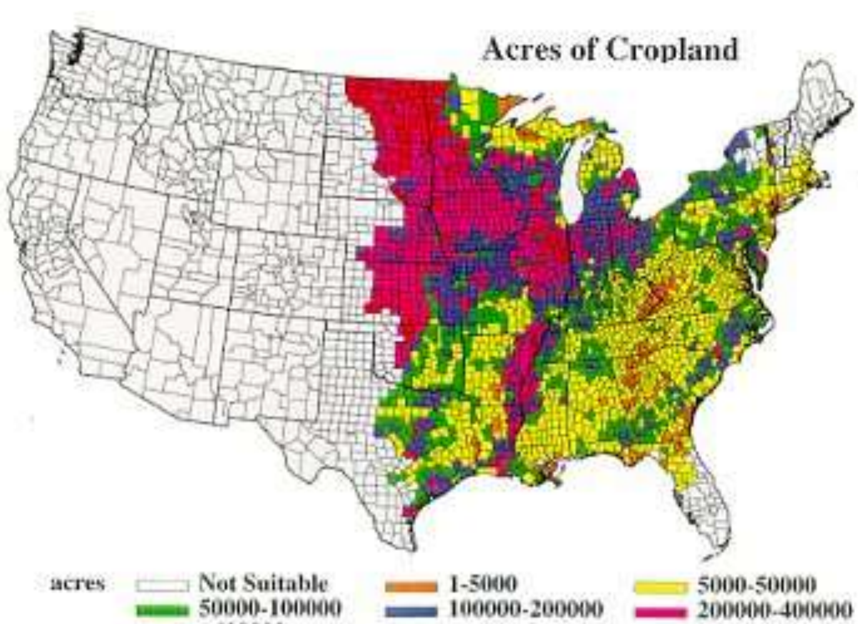

Figure 5.7. Acres of Cropland Suitable for Switchgrass

Source: ORNL's "A National Assessment of Promising Areas for Switch grass, Hybrid Poplar, or Willow Energy Crop Production"

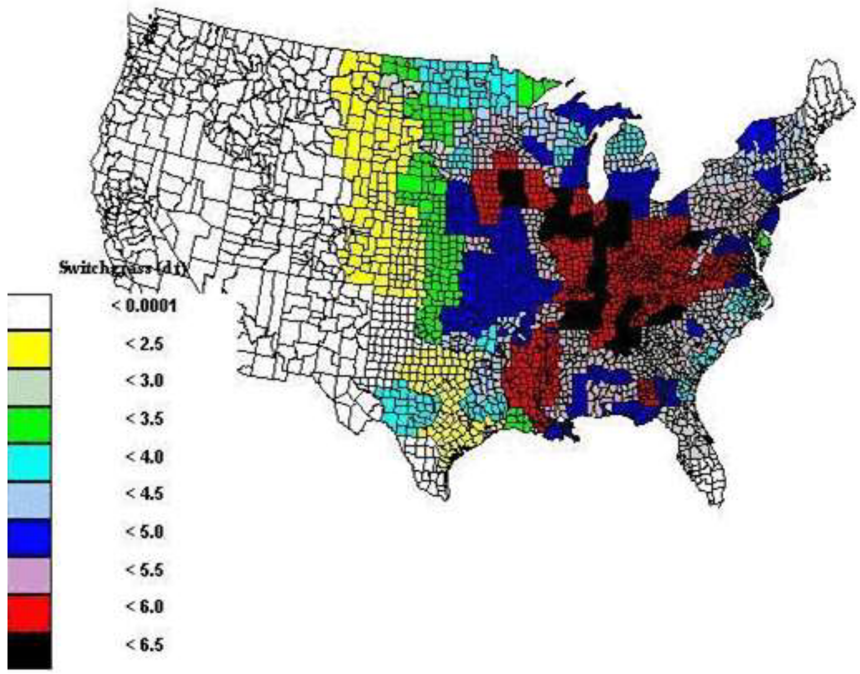

Figure 5.8. Average Switchgrass Yields in Dry Ton
Source: ORNL's "A National Assessment of Promising Areas for Switch grass, Hybrid Poplar, or Willow Energy Crop Production"

Geothermal

Geothermal reservoirs are naturally occurring areas of underground hydrothermal resources. When magma comes near the earth's surface, it heats ground water trapped in porous rock or water running along fractured rock surfaces.

Geothermal reservoirs are largely undetectable from the earth's surface. Areas with the greatest potential for geothermal energy are usually located along major tectonic plate boundaries. Earthquakes, volcanoes, hot springs, and geysers are signs of geothermal energy. To identify the geothermal resources in an area, geologists drill a well and test the temperature deep underground. Some geothermal wells may be as deep as two miles. Most of the geothermal power plants in the U.S. are located in western states and Hawaii where geothermal resources are close to the earth's surface.

Geothermal resources in Tennessee are not favorable. The bulk of the state is either not available or least favorable for deep enhanced geothermal systems (see Figure 5.9).

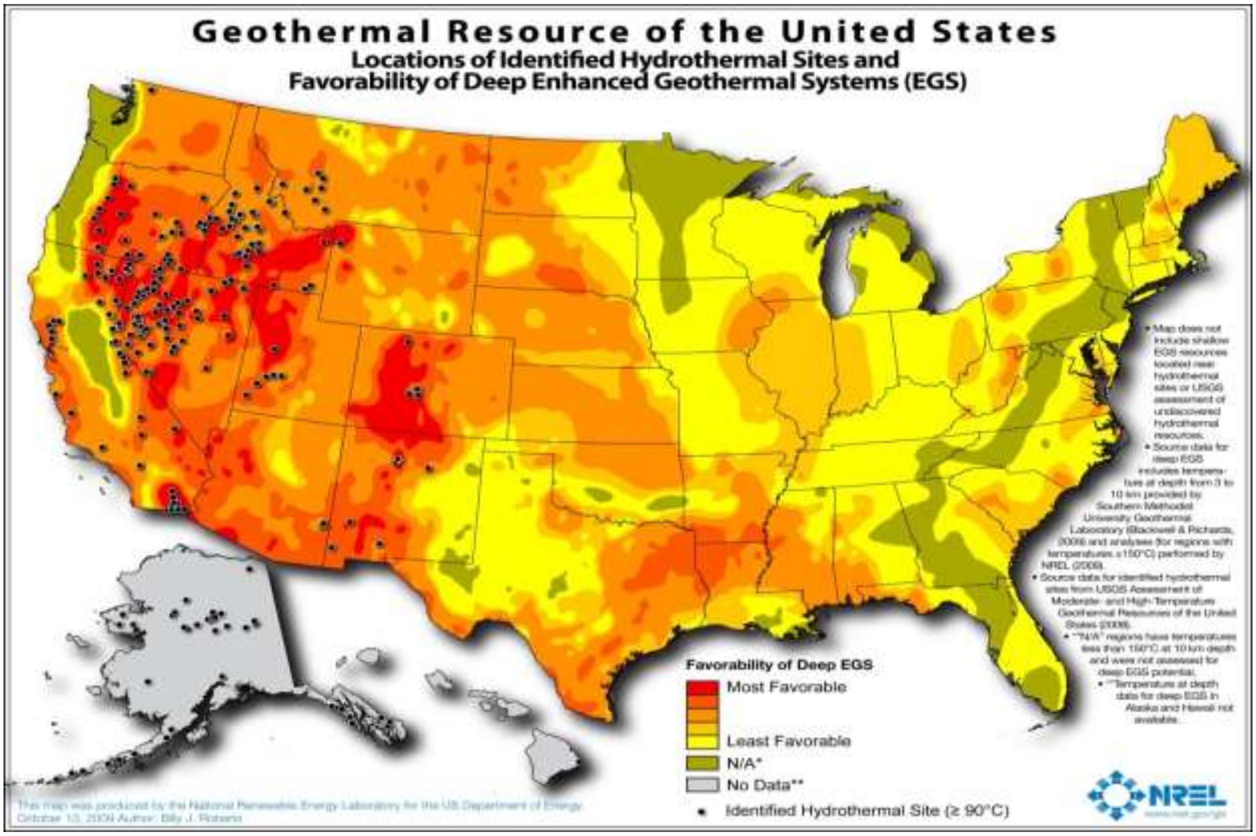

Figure 5.9. Geothermal Resources of the U.S.

Solar

There is some potential for solar in Tennessee based on data presented by NREL (see Figure 5.10). The potential for solar is further supported by TVA's map of solar facilities existing across the TVA region (see Figure 5.11). Solar installations have grown over the last several years. Some of the growth in installations can be attributed to the Volunteer State Solar Initiative (VSSI). More than 6.7 megawatts were added to the state through the Tennessee Solar Institute installation grant program. The West Tennessee Solar Farm added 5 megawatts. While the VSSI was instrumental, there has been a growth in residential arrays and large-scale installations. For example, the Chattanooga airport has a 1 megawatt array. Although TVA has some restrictions on the amount of solar added to the grid on an annual basis, there are more than 2,000 participants across the Valley.

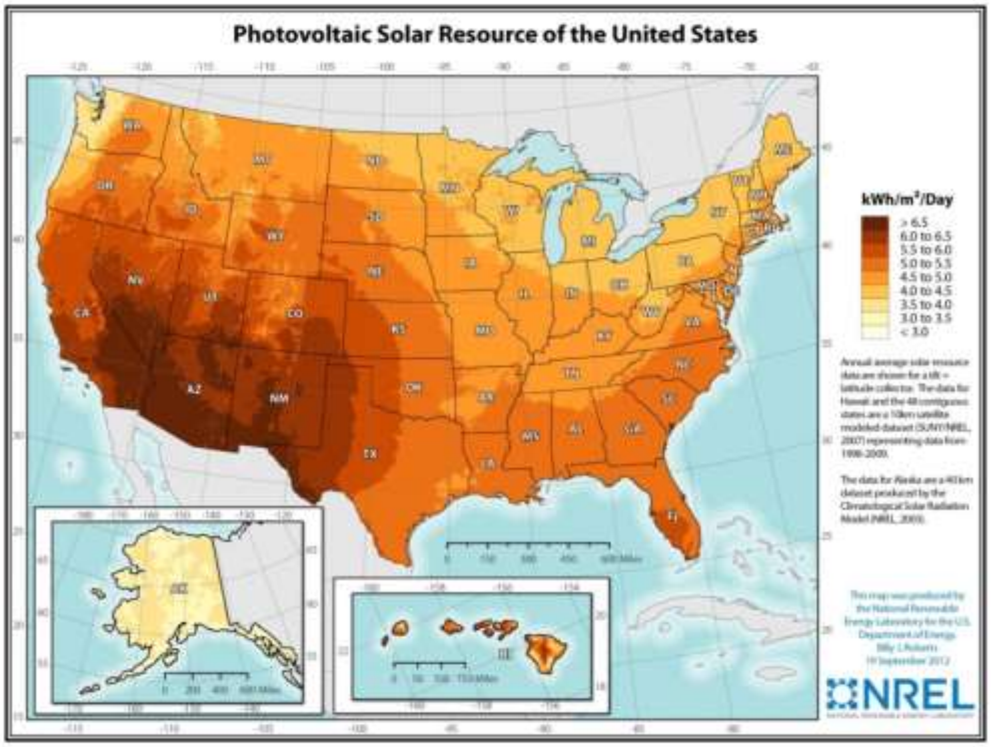

Figure 5.10. Photovoltaic Solar Resources of the U.S.

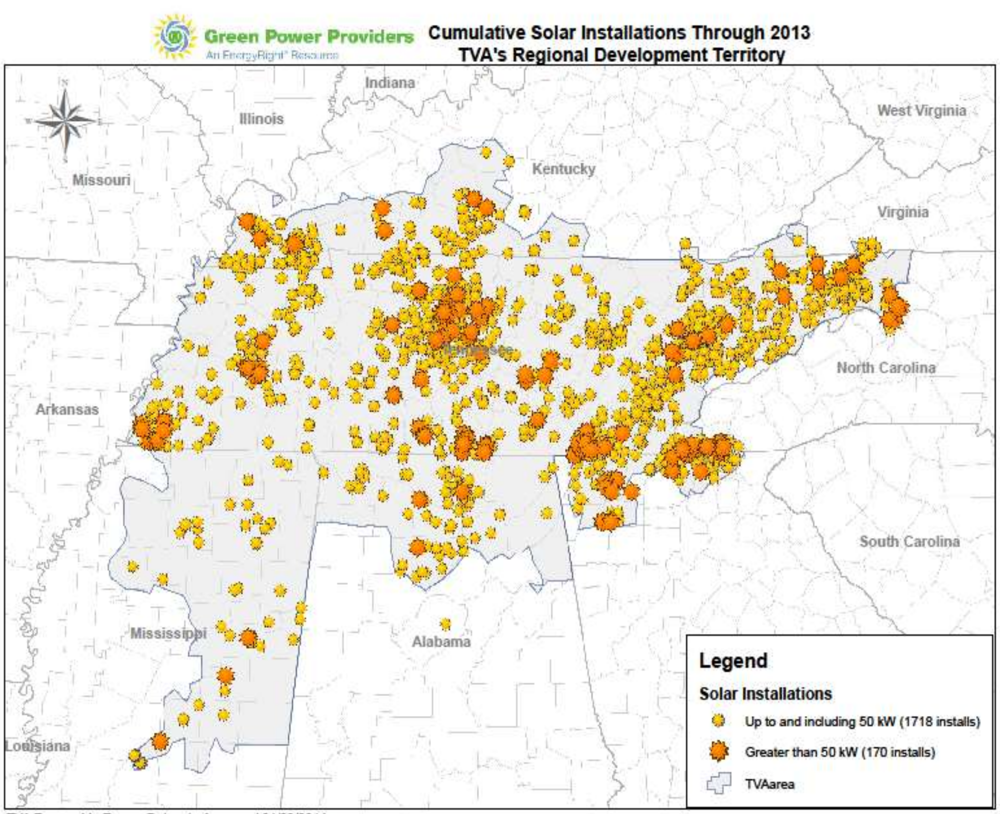

Figure 5.11. Cumulative Solar Installation through 2013 in TVA's Regional Development Territory

Wind

The prospective for wind does not look as promising in Tennessee. Lower wind speeds are observed in Tennessee and the Southern states (Figure 5.12). Higher wind potential is located in the western part of the state where the flat and open landscape tends to result in higher wind speeds. However, average wind speed can vary significantly over a small area depending on local topography. Smaller wind farms are often sited in mountainous areas where local conditions are favorable such as at the mouth of canyons and on certain ridge tops. This suggests that smaller wind farms may still be possible in the eastern part of the state if siting carefully considers local topography.

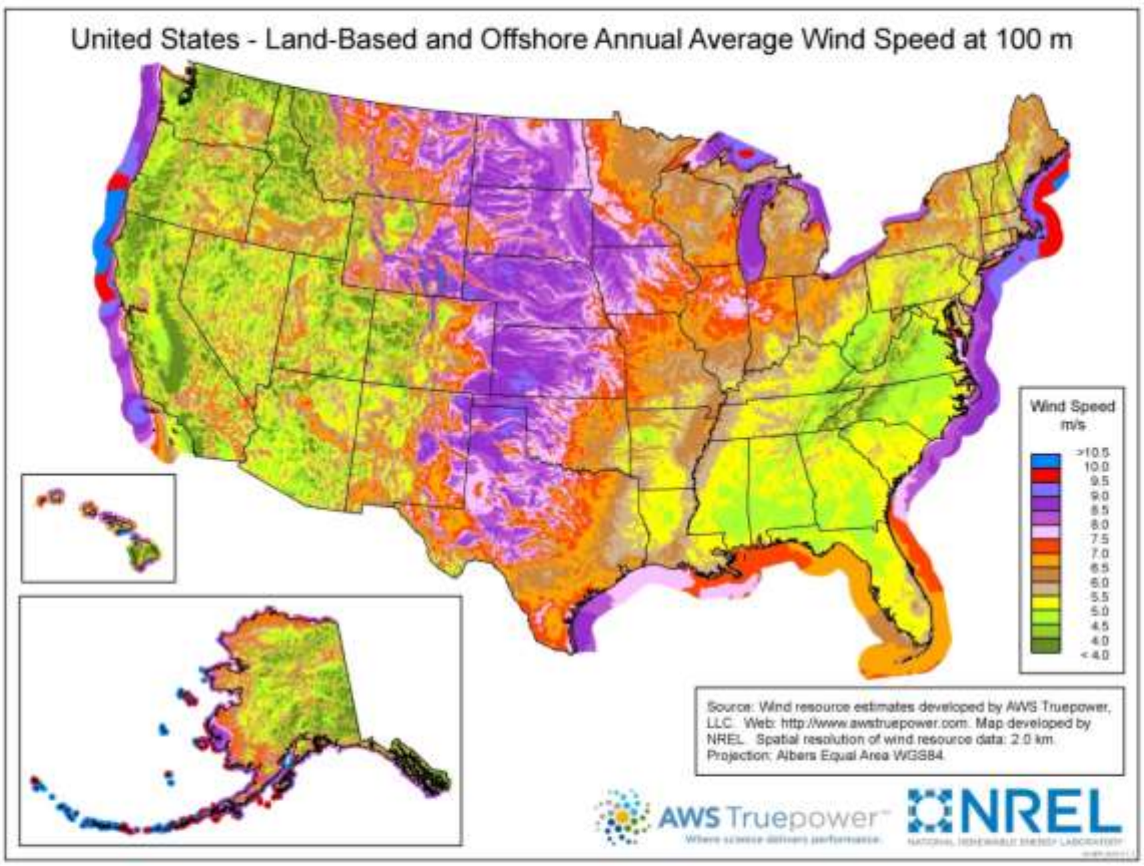

Figure 5.12. U.S. Land-based and Offshore Annual Average Wind Speed at 100m

Energy Production

Primary energy production includes the extraction, harvesting, refining, and processing of primary energy (fuel) sources that are used by end-use sectors (residential, commercial, industrial, transportation) or secondary energy production (electric power generation). (See Chapter 3 for a broad overview.) Tennessee has coal, oil, and shale gas resources but not all are in deposits large enough or high grade enough to recover under present economic conditions. Tennessee extracts coal, natural gas, and crude oil, and produces biofuels that serve as primary energy sources (see Figure 5.13). Depending on market forces, these products may be exported outside Tennessee or remain in the state allowing for domestic sources of primary energy production. In 2012, Tennessee produced a total of 67.3 trillion Btu of fuel sources. The biggest primary energy fuel source in the state is biofuels (45 percent) followed closely by coal (42 percent). As a percentage of total production, **Tennessee tends to produce more biofuels and coal and less natural gas and crude oil than the country as a whole.**

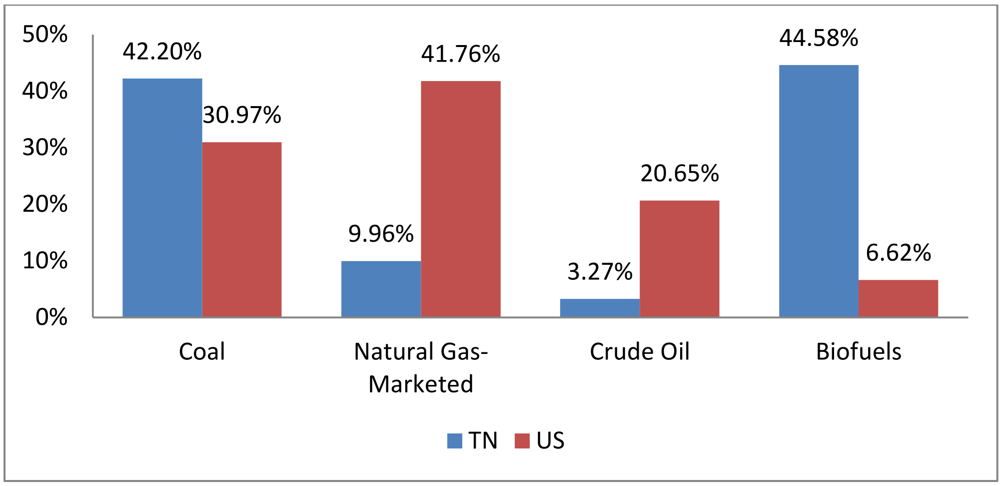

Figure 5.13. Primary Energy Production, 2012 *Source: http://www.eia.gov/state/?sid=TN#tabs-3*

Primary energy production also provides jobs for Tennesseans. Figure 5.14 shows total employment for occupational codes related to primary energy production.[162] These jobs range from rock splitters and mine machine operators to geological engineers and petroleum technicians. A more in-depth look at employment in each primary energy category is presented below.

[162] These employment estimates exclude the self-employed.

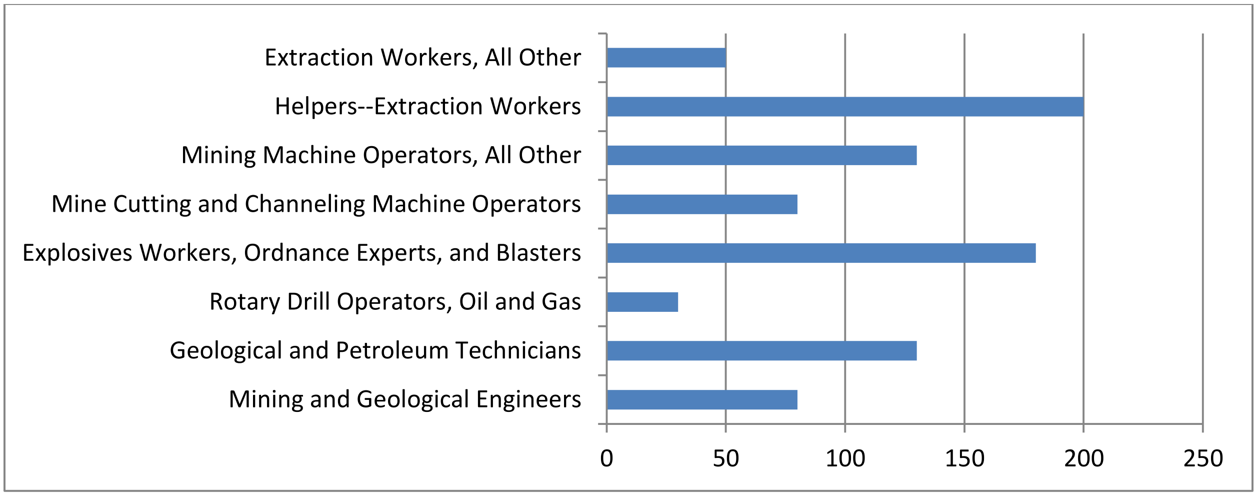

Figure 5.14. Total Employment in Primary Energy Production in Tennessee in 2013
Source: Bureau of Labor Statistic, Occupational Employment Statistics (http://www.bls.gov/oes/)

Coal

Tennessee produced 1.15 million gross tons of coal in 2012 ranking it fifth lowest among the 25 coal producing states.[163] Even though coal's share of primary energy production is larger in Tennessee than the rest of the country, Tennessee is still a relatively small coal producer (and relatively large coal importer). In 2013, Tennessee production increased to 1.20 million gross tons. However, there has been a general declining trend in coal production in the state over the past decade both in terms of gross tonnage mined and number of mines (see Figure 5.15).

This declining trend in production in the state is consistent with regional trends. Coal production from the Appalachian Basin has also been in decline due to lower natural gas prices and domestic concerns over the environment. In response to decreased demand in the U.S., coal exports have increased by 166 percent over the past decade.[164] Exports are especially critical for Appalachian Basin producers whose high-sulfur-content coal is in less demanded by domestic customers due to environmental regulations. In 2013, Europe (52 percent) and Asia (27 percent) accounted for over three quarters of U.S. coal exports.[165] However, coal exports have declined for five quarters in a row. Between June 2013 and June 2014 U.S. coal exports dropped nearly 15 percent. While exports dropped in nearly all world markets,[166] the drop was most pronounced in Asia where coal exports from the U.S dropped nearly 30 percent over the 12 month period. In September, 2014 China (the

[163] EIA SEDS database (http://www.eia.gov/state/?sid=TN)
[164] Global Trade Information Services
[165] Table 7, EIA Quarterly Coal Report, 2nd Quarter, Released October 8, 2014.
[166] Exports to Africa increased 45%.

world's largest coal importer) announced it would ban the use of imported coal with more than 16 percent ash and 1 percent sulfur for some users starting January 1, 2015 in a bid to improve air quality.[167] In October, the Chinese Ministry of Finance announced that import tariffs for metallurgical coal would be reinstated at 3 percent with a 6 percent tariff on thermal coal.[168]

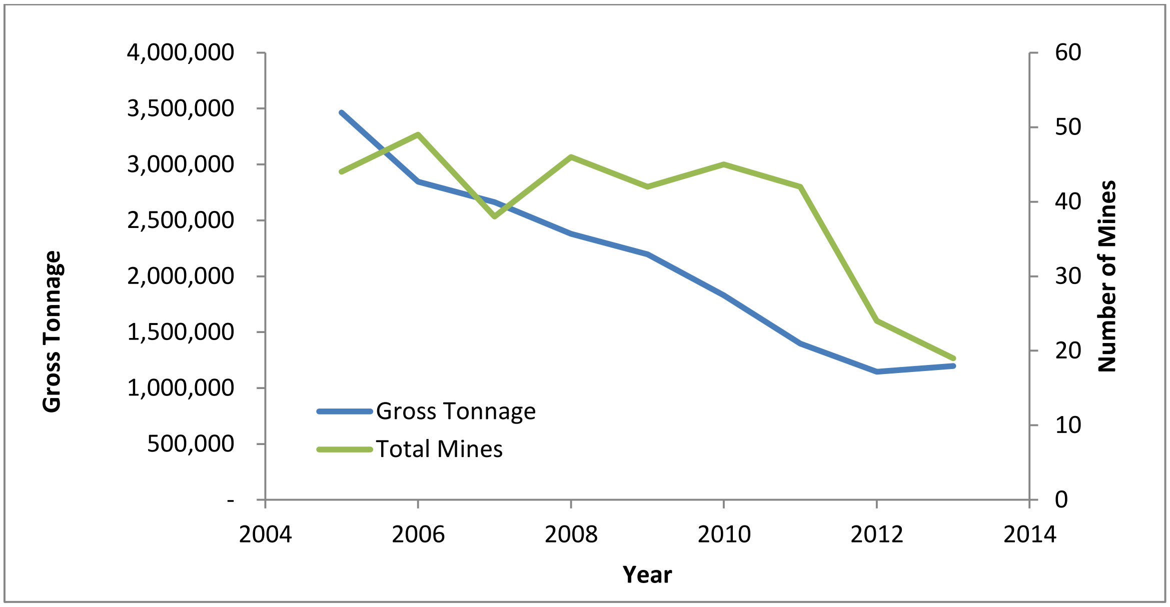

Figure 5.15. Tennessee Coal Production 2005-2013 *Source: Federal Office of Surface Mining, Appalachian Regional Office*

The decline in gross tonnage has been most pronounced among surface mines (see Figure 5.16). The choice between surface and underground mines depends on 1) size, shape, and depth of deposit, 2) rock conditions, 3) productivities and machinery capacities, 4) capital requirements and operating costs, 5) ore recoveries and revenues, 6) worker safety, and 7) environmental impacts. For much of the last decade, a large share of Tennessee's coal has been produced from surface mines. As recently as 2011, surface mining accounted for nearly 70 percent of total coal tonnage produced in the state. However, by 2013 surface mining accounted for less than 40 percent of coal produced.

[167] http://www.cnbc.com/id/102002818#. Accessed November 19, 2014.
[168] http://www.reuters.com/article/2014/10/09/china-coal-idUSL3N0S41QP20141009 Accessed November 19, 2014.

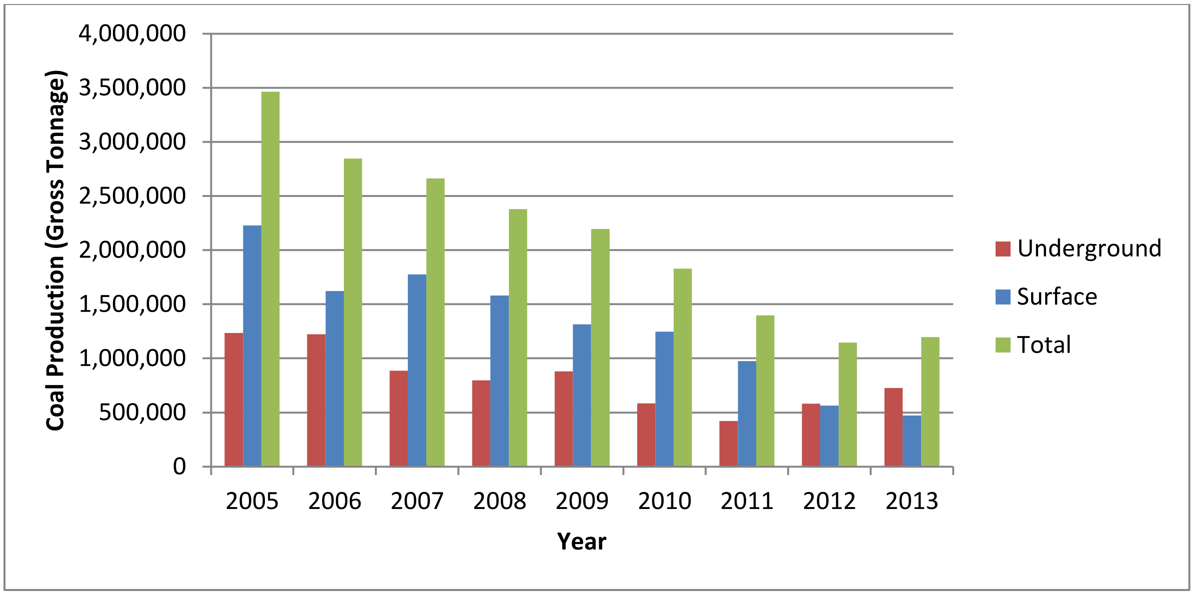

Figure 5.16. Tennessee Coal Production by Mine Type, 2005-2013 *Source: Federal Office of Surface Mining, Appalachian Regional Office*

The decline in the total number of coal mines has also coincided with a shift from operating to non-operating mines (see Figure 5.17). Many coal mines in Tennessee are capable of coming online for short periods of time in response to market conditions. As a result, the total number of mines captures both operating mines that are currently producing coal and non-operating mines that have temporarily halted production. In Tennessee, the total number of mines has declined in recent years and, of those mines that remain, an increasing percentage is not operating.

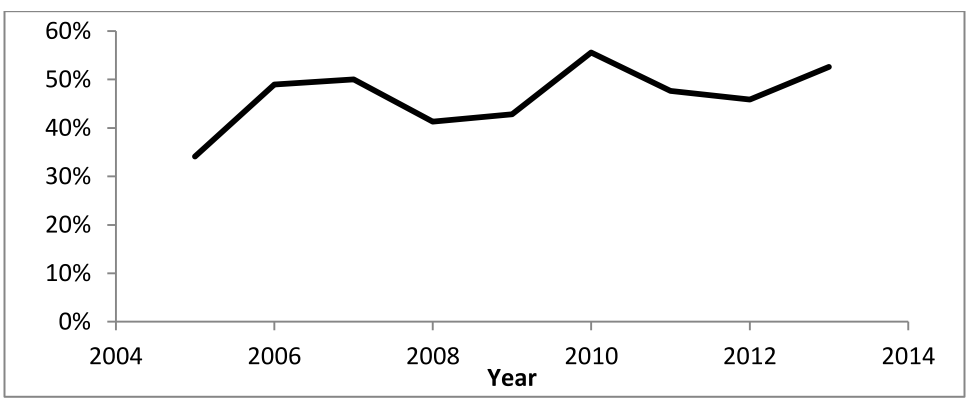

Figure 5.17. Percentage of Tennessee Coal Mines Not Operating, 2005-2013 *Source: Federal Office of Surface Mining, Appalachian Regional Office*

The mines that remain in Tennessee are being operated by fewer mining companies. The number of mining companies in the state decreased from 15 in 2005 to 7 in 2013 (see Figure 5.18). This declining trend in production has terminated coal mining operations in many parts of the state such as Cumberland, Fentress, Grundy, and Scott Counties and concentrated coal production in three counties: Anderson, Campbell and Claiborne.

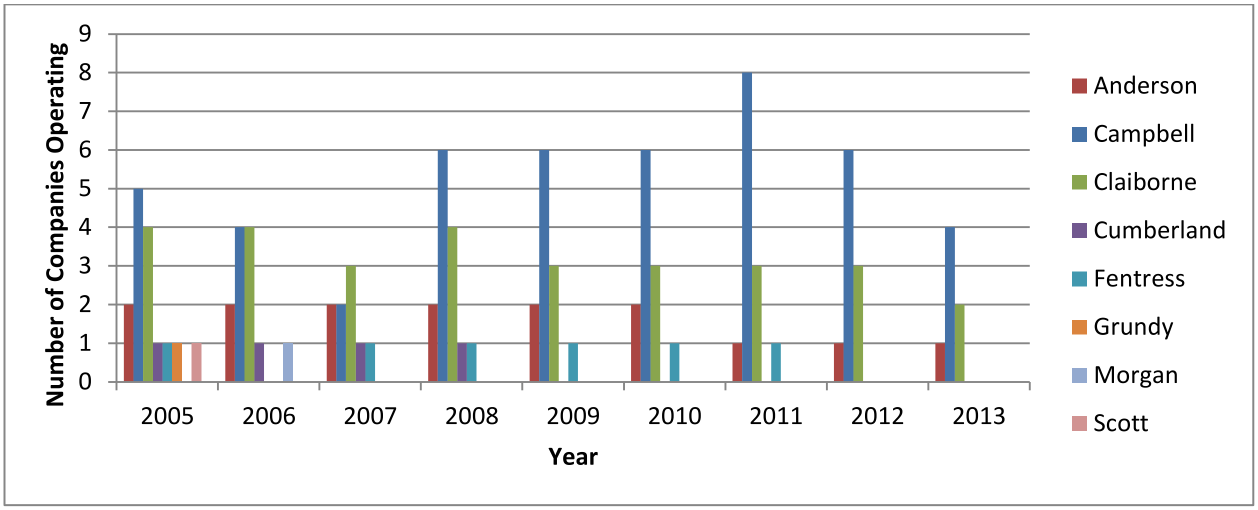

Figure 5.18. Number of Companies Mining in Tennessee from 2005-2013. *Source: Federal Office of Surface Mining, Appalachian Regional Office*

Employment in the state's coal industry has declined in recent years as well. According to the U.S. Mine Safety and Health Administration (MSHA), coal industry employment has fallen by nearly 60 percent in the past five years (see Figure 5.19). There were just 325 employees in the coal mining industry in Tennessee in 2013, well below the level of employment that prevailed in 2000. It is difficult to say how many of these 325 employees are Tennessee residents since many of the operating mines that remain in Campbell and Claiborne County are near the Kentucky border.

Figure 5.20 shows differences in employment and worker hours across different occupations with in the coal industry. Underground mining operations account for 45 percent of Tennessee coal industry employment while surface mining operations (strip, quarry, open pit) account for 40 percent. The average work week in an underground mine is also slightly higher at 31.85 hours.

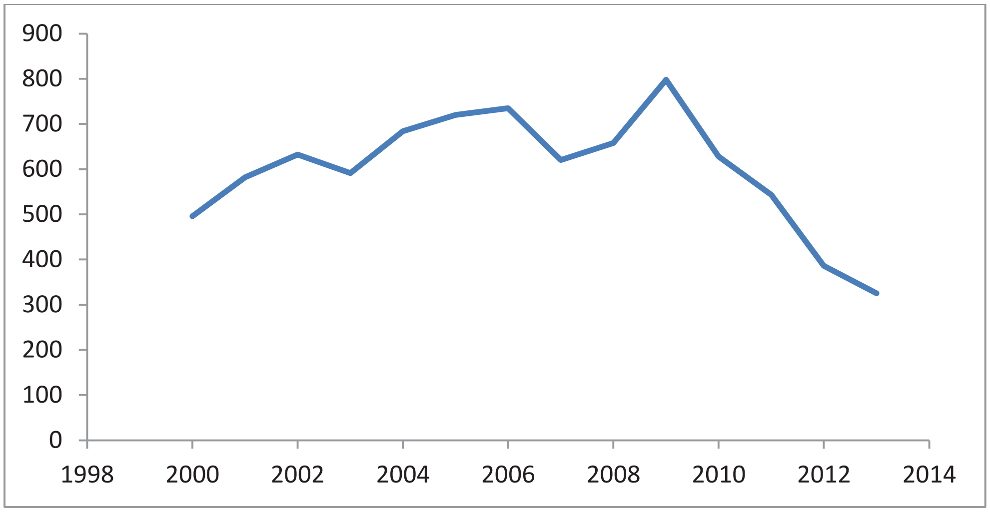

Figure 5.19. Tennessee Coal Industry Employment.
Source: U.S. Mine Safety and Health Administration

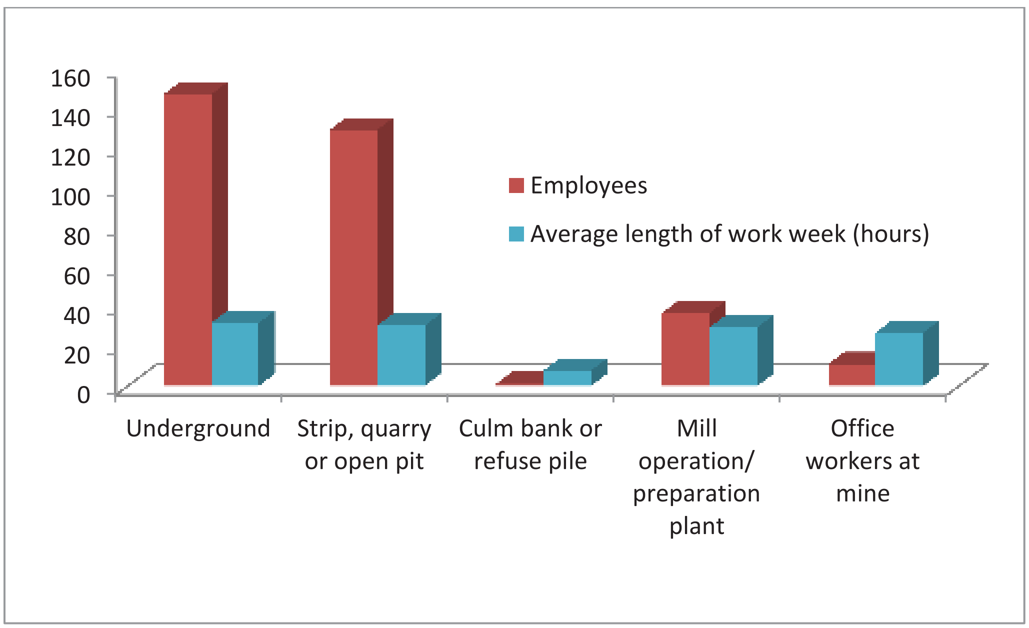

Figure 5.20. Employment and Worker Hours in Different Occupations within the Tennessee Coal Industry, 2013.
Source: *U.S. Mine Safety and Health Administration*

The mine price for coal, which excludes transportation and insurance costs, reflects the value of coal produced in Tennessee. Mine prices can vary due to differences in coal quality (energy, water, and sulfur content), access to coal markets, and public versus private ownership of coal reserves. Coal mined in the eastern part of the country generally has a higher energy content making it more valuable. Coal mined in the eastern part of the country is also closer to markets and the larger coal export terminals in Baltimore, Norfolk, New Orleans, Mobile and Houston. However, coal mined in the eastern part of the country generally has a higher sulfur content (see Table 3.2) making it less valuable for domestic customers with environmental concerns. Eastern reserves are also primarily privately owned while western reserves are generally owned by federal agencies (primarily the Bureau of Land Management).[169] Federal regulations are thought to lower the cost of mining on public lands. According to EIA's *State Profile and Energy Estimates Database*, the average price of coal received by coal mines in Tennessee in 2012 was $73.51 per short ton (see Figure 5.21). This is a drop of 1 percent from 2011 prices but still ranks Tennessee as having the fourth highest coal sales price among coal producing states behind Virginia, Alabama, and West Virginia. By comparison, the U.S. average mine price for coal in 2012 was $39.95 per short ton, down 2.6 percent from 2011. EIA calculates an average sales price by dividing the total free on board (f.o.b) rail/barge value of the coal sold by the total coal sold. This procedure excludes mines producing less than 25,000 short tons which are not required to provide data. This price also excludes silt, culm, refuse bank, slurry dam, and dredge operations.

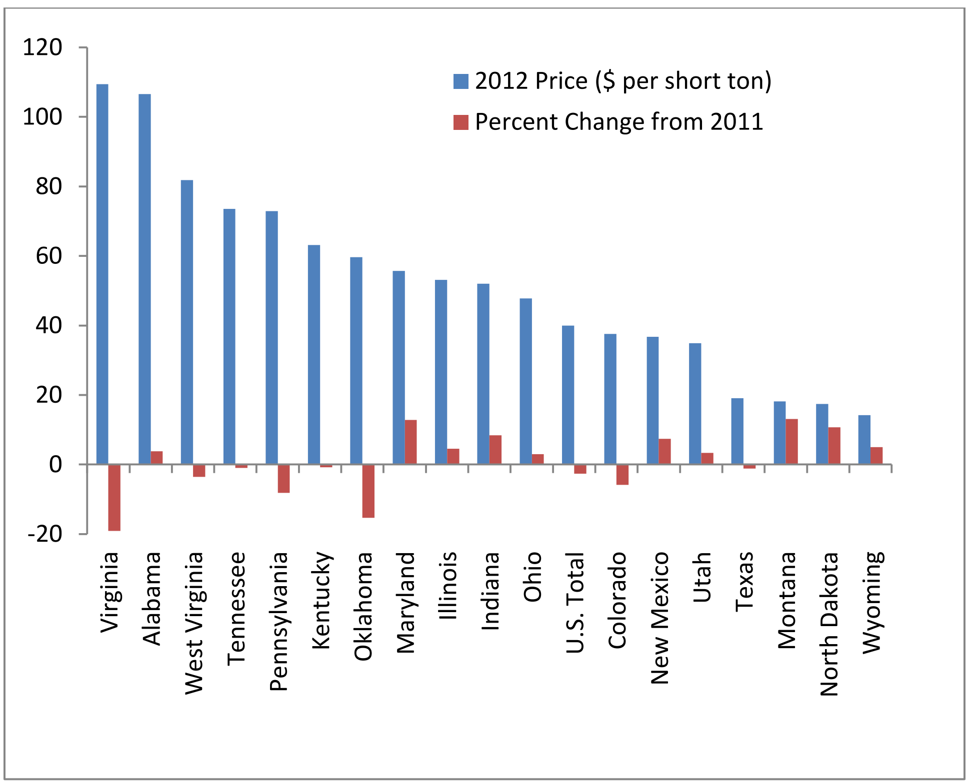

Figure 5.21. Prices Received by Coal Mines in Coal-producing States.
Source: Table 28 EIA SEDS database (http://www.eia.gov/state/data.cfm?sid=TN)

[169] e.g., Federal Coal Lease Program, Fair Market Value, and Royalty Payment: Lost Revenue for State Governments. Tom Sanzillo. Institute for Energy Economics and Financial Analysis. http://www.ieefa.org/presentations/ Accessed December 1, 2014.

Determining where coal mined in Tennessee is ultimately being used as a primary fuel source is difficult. Most coal producers in Tennessee in 2013 (the last year production data are available) were not required to report production data to EIA due to small quantities produced. However, there are a couple of reasons to infer that much of the coal mined in Tennessee is being exported outside the state. First, most of the coal produced in Tennessee has historically been sent to coal-fired power plants in neighboring states.[170] Second, none of TVA's coal-fired power plants in Tennessee, the largest consumer of coal in the state, received coal shipments from mines in Tennessee. Therefore, it is unlikely that coal is being used for energy generation in the state.

Natural Gas

Tennessee ranked among the lowest 10 producing states in marketed natural gas production in 2012 with 5,825 million cubic feet (see Figure 5.22).[171] This relatively low level of production in the state follows a near doubling of production over the past decade. By comparison, U.S. natural gas production increased by less than 30 percent over this same time.

Each well in the state also became more productive over the last decade. While natural gas production in the state has doubled over the past decade, the number of wells has been cut in half. This downward trend in the number of wells runs counter to larger trends across the country where the number of gas wells has increased by 25 percent. These trends have brought Tennessee's production per well measure (22 MMcf per well) closer to the national average (38 MMcf per well). Since shale gas exploration is undertaken by drilling test wells, this suggests that Tennessee producers have curtailed exploration efforts and are instead focusing operations on their most productive wells.

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[170] EIA Coal Data Browser, http://www.eia.gov/beta/coal/data/browser/

[171] EIA *State Profile and Energy Estimates Database,* http://www.eia.gov/state/data.cfm?sid=TN.

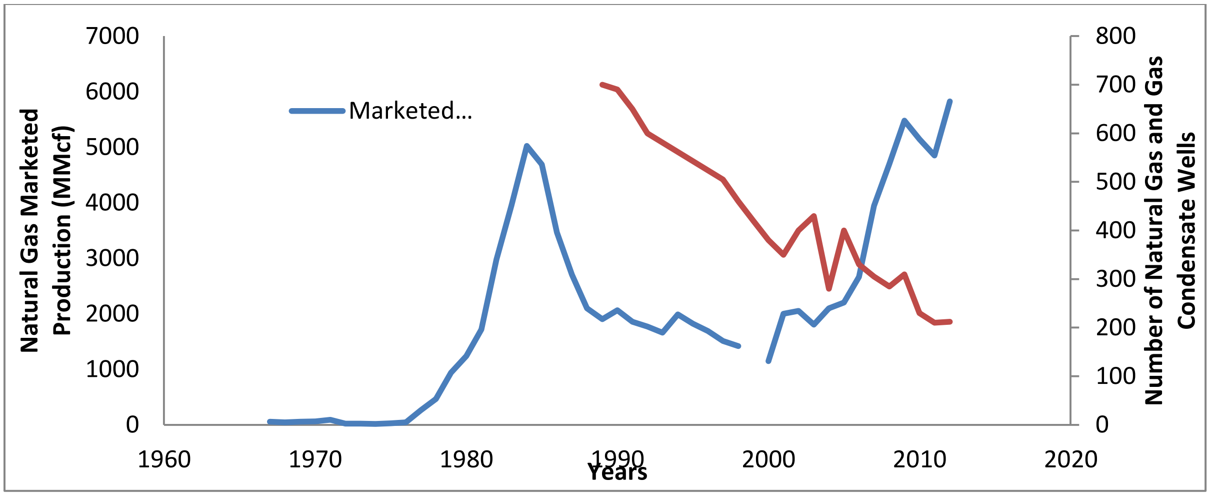

Figure 5.22. Natural Gas Production in Tennessee, 1967-2012.
Source: EIA SEDS database (http://www.eia.gov/state/data.cfm?sid=TN)

Determining where natural gas production is taking place in the state is difficult. Because commercial drilling activity provides information on the quantity of the resource in the area, companies treat information on the location and production of oil and natural gas wells as proprietary information. However, anyone who drills, deepens, or reopens oil and gas wells must obtain a permit from the Tennessee Department of Environment and Conservation (TDEC). While a permit does not necessarily imply production is currently taking place, a general picture can be obtained by looking at where oil and gas well permits are registered. Figure 5.23 summarizes the location of permits in TDEC's Oil and Gas Well Database as of September 23, 2014. Much of the well drilling activity is confined to the Cumberland Mountains and Plateau. The top three counties for total number of oil and gas well permits are Overton (2943), Morgan (2202), and Fentress (1988). Natural gas produced in the state is added to the interstate natural gas pipeline system. This makes it difficult to determine what proportion of natural gas produced in Tennessee is also consumed in Tennessee.

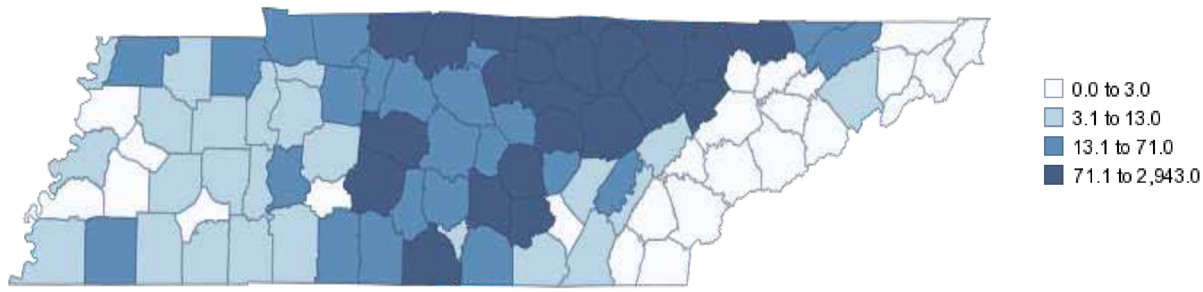

Figure 5.23. Oil and Gas Well Permits
Source: Tennessee Department of Environment and Conservation Oil and Gas Well Database (http://www.tennessee.gov/environment/permits/oilgas.shtml)

Natural gas markets are currently regional due to the nature of the natural gas pipeline system in the country and limited infrastructure needed for exporting natural gas overseas. Regional markets mean that the price currently received for natural gas produced in Tennessee may differ from the average natural gas prices received by producers in other parts of the country. The rapid expansion of natural gas development in the U.S. has outpaced the ability of companies to build the infrastructure needed to export that gas to regional markets. As recently as five years ago, many companies built natural gas import terminals anticipating greater U.S. demand for imported fuel. Now many of these plans to build import terminals are being scrapped in favor of export terminals.[172] For example, in 2013, the Department of Energy approved a privately-funded project that would convert a natural gas import terminal in Texas into an export terminal. The development of these export facilities is expected to make regional gas markets more responsive to global market forces and increase domestic natural gas prices. If this increase is large enough, interest in Tennessee's Chattanooga shale plays may re-emerge.

The value of extracted natural gas in the state is captured by the wellhead price. According to EIA, U.S. natural gas wellhead prices averaged $2.66 per thousand cubic feet in 2012. Figure 5.24 shows that this price represents a 67 percent decrease over the preceding five years. EIA discontinued its calculation of natural gas wellhead prices in January 2013. The most recent data available for wellhead natural gas prices in Tennessee (2010) indicates that natural gas produced in the state sold for an average of $4.35 per thousand cubic feet. This was slightly lower than the U.S. average at the time ($4.48 per thousand cubic feet).[173] Given the strong correlation between U.S. and

[172] http://www.nytimes.com/2014/09/30/business/energy-environment/a-u-turn-for-a-terminal-built-in-texas-to-import-natural-gas.html Accessed December 1, 2014.
[173] EIA SEDS database, http://www.eia.gov/state/data.cfm?sid=TN. Accessed October 16, 2014.

Tennessee wellhead prices (see Figure 5.24), the current price received for natural gas priced in Tennessee is likely below $4 per thousand cubic feet. Once the natural gas is extracted, it must be processed in order to be used as a fuel source. Tennessee has no natural gas processing facilities.

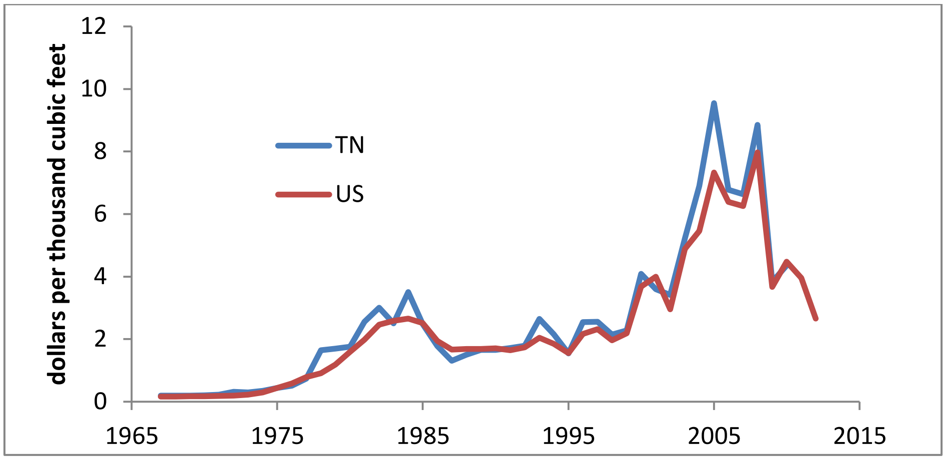

Figure 5.24. Natural Gas Wellhead Prices, 1967-2012
Source: EIA SEDS database (http://www.eia.gov/state/data.cfm?sid=TN)

Citygate prices reflect the price paid by a distributing gas utility once it receives gas from a natural gas pipeline company or transmission system. Figure 5.25 shows citygate prices for natural gas in Tennessee and the U.S. as a whole. For much of the past 20 years, natural gas citygate prices in Tennessee have been at or above the national average. Over the past four years, citygate prices in Tennessee have been below the national average. As of 2013, natural gas citygate prices in the state were $4.73. In 2010, when wellhead prices in the state were $4.35 per thousand cubic feet, citygate prices in the state were $5.78 per thousand cubic feet. This difference represents the additional cost of processing and transporting natural gas.

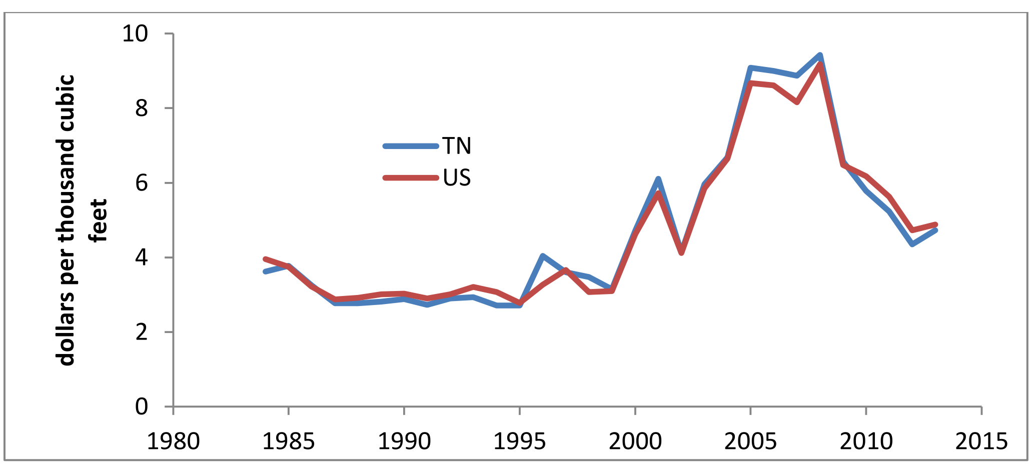

Figure 5.25. Natural Gas Citygate Prices, 1984-2013.
Source: EIA SEDS database (http://www.eia.gov/state/data.cfm?sid=TN)

Crude Oil

Tennessee ranked among the lowest 10 producing states in crude oil production in 2013 with only 309,000 barrels.[174] Figure 5.26 shows Tennessee crude oil production from 1981-2013. Crude oil production has trended down over the last decade with current levels being considerably lower than the peak of Tennessee crude oil production in 1982. Between 2012 and 2013, Tennessee production dropped 17 percent. By comparison, U.S. crude oil production increased by 32 percent over the past decade and increased 14 percent between 2012 and 2013.

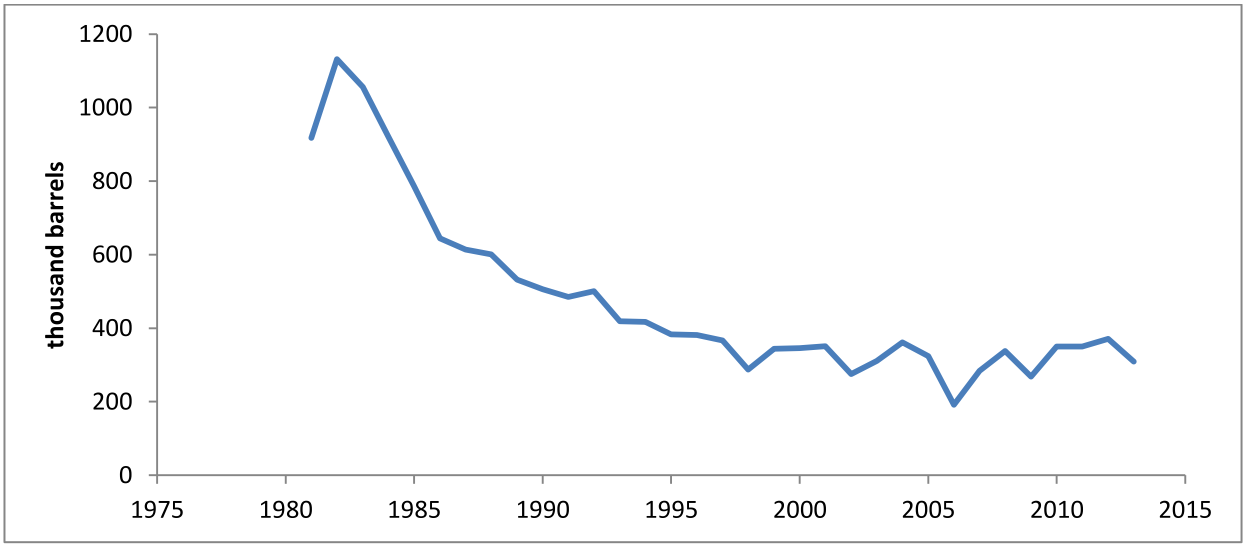

Figure 5.26. Tennessee Crude Oil Production, 1981-2013
Source: EIA SEDS database (http://www.eia.gov/state/data.cfm?sid=TN)

Similar to natural gas, determining where crude oil production is taking place in the state is difficult as the productivity of wells is viewed as proprietary information. As seen previously, Figure 5.23 summarizes the location of permits in TDEC's Oil and Gas Well Database as of September 23, 2014. While a permit does not necessarily imply production is currently taking place, much of the well drilling activity is confined to the Cumberland Mountains and Plateau. The top three counties for oil and gas well permits are Overton (2943), Morgan (2202), and Fentress (1988).

Unlike natural gas, oil transport and export infrastructure is well developed. This subjects local producers to the forces of a global crude oil market. EIA reports domestic crude oil first-purchase prices which represents the price received for domestic crude oil extraction. Unfortunately, the limited amount of production in the state prevents EIA from reporting this price for Tennessee. As

[174] http://www.eia.gov/state/data.cfm?sid=TN

a proxy for the value of crude oil produced in Tennessee, Figure 5.27 reports the domestic crude oil first-purchase price for many neighboring states as well as the U.S. average.

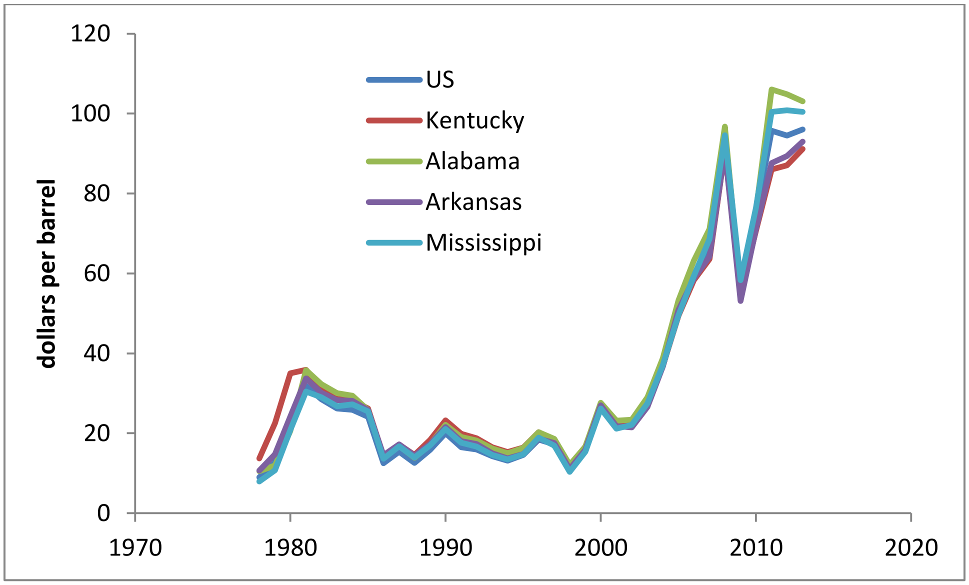

Figure 5.27. Domestic Crude Oil First Purchase Price, 1978-2013
Source: EIA SEDS database (http://www.eia.gov/state/data.cfm?sid=TN)

Once the crude oil is extracted it must be refined to be used as a fuel source. Tennessee is home to one of the country's 139 operating petroleum refineries. The Valero Memphis Refinery (formerly Premcor) can process about 180,000 barrels of crude oil per day and employs approximately 310 individuals. The refinery produces motor gasoline, diesel fuel, jet fuel and petrochemicals. It receives crude oil from the Capline pipeline that crosses through western Tennessee on its route between the Gulf Coast and Midwest refineries. Thus much of the crude oil produced in the eastern portion of the state is refined elsewhere. Out-of-state refining capacity and the nature of the crude oil pipeline system makes it difficult to determine the amount of domestically produced crude oil consumed in Tennessee.

Biofuels

In 2013, Tennessee was the 13th largest producer of biofuels in the country with 30 trillion Btu.[175] Most of this biofuel was produced from switchgrass, corn stover, and short rotation woody crops. Regional market prices for these crops are not well-established.[176]

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175 EIA *State Profile and Energy Estimates*, http://www.eia.gov/state/?sid=TN#tabs-3

176 The most recent estimates for the state of Tennessee come from a 2001 study by Oak Ridge National Lab, Graham, R. and M. E. Wash. 2001. *A National Assessment of Promising Areas for Switch grass, Hybrid Poplar, or Willow Energy Crop Production*. ORNL-6944, Bioenergy Feedstock Development Program, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN. According to this study, based on 2000 cropland use

A demonstration-scale cellulosic ethanol biorefinery has been constructed in Vonore, Tennessee, through the state-sponsored University of Tennessee Biofuels Initiative. Cellulosic ethanol is made from crop waste and non-food crops. It can produce four to ten times more energy than corn ethanol.[177] The Vonore facility has the capacity to produce 250,000 gallons of ethanol per year from energy crops such as swithcgrass and crop residues such as corn cobs.

In addition to cellulosic ethanol, Tennessee also produces corn ethanol and biodiesel. Green Plains Renewable Energy operates a 120-million-gallon ethanol plant in Obion, Tennessee. Tate & Lyle operates a 105-million-gallon ethanol plant in Loudon County. Biodiesel firms include Green Gallon Solutions in Cookeville and Sullens Biodiesel in Morrison.

BioEnergy Science Center

The BioEnergy Science Center, funded by DOE and located at ORNL, was established in 2007. The Center is dedicated to accelerating research toward the development by 2017 of advanced biofuels that can be produced at $3.00 per gallon.

Biofuels Initiative

In 2007, the state legislature appropriated $70.5 million for the creation of the University of Tennessee Biofuels Initiative. The goal of this initiative was to develop and commercialize cellulosic biofuels. When the Biofuels Initiative expired in 2012, two companies were formed to carry on the initiative's vision. TennEra conducts general research and development focused on technologies and processes for separating cellulosic biomass components and commercial application for biorefinery co-products. Genera Energy provides integrated, commercial biomass supply solutions for the advanced biofuels, biopower, and biobased products industries. Genera designed, built, and operates the Biomass Innovation Park in Vonore. In operation since 2011, the Biomass Innovation Park is the nation's only commercial facility that can perform all the processes necessary to bridge "the farm gate and the biorefinery gate," ranging from biomass receiving and inventory management to size reduction and characterization.

patterns and estimates of likely energy crop yields ,Tennessee switchgrass farmgate prices in TN were estimated at $34.89 per dry ton (2000 dollars). Switchgrass prices were estimated to be between $25 and $30/dry ton for virtually all of the eastern two-thirds of the state. The higher density of existing cropland and better soils in the western part of the state were estimated to yield a farmgate price of $30 to $35 per dry ton.

[177] Worldwatch Institute, "Smart Choices for Biofuels", p.8

CHAPTER 6. ENVIRONMENT AND HEALTH

By Charles Sims, PhD, Howard H. Baker Jr. Center for Public Policy

Key Points

Resource extraction for energy production, energy production and energy consumption can impact human health and the environment in a number of ways. Mining and drilling activities that produce primary energy sources can have impacts on local air quality, water quality and negatively impact the natural beauty of Tennessee. Even after production has ceased, abandoned mines and well sites can have human health and safety impacts that linger for years. Fossil fuel combustion produces pollutants that have regional and global impacts. Preventing and alleviating these and other impacts requires effective environmental policies and regulations at the state and federal levels that balance environmental protection with economic development. State and federal agencies must then work together to ensure these policies are enforced.

This chapter highlights **environmental and health concerns related to the consumption and production of energy in Tennessee.** Key findings include:

- Air pollutants such as PM2.5, nitrogen oxides, sulfur dioxides, and ground-level ozone have been linked to asthma, chronic obstructive pulmonary disease (COPD), heart attack, stroke, and lung cancer.
- Six counties in eastern Tennessee **(Anderson, Blount, Hamilton, Knox, Loudon, Roane) do not meet** (or contribute to air quality in a nearby area that does not meet) national air **quality standards for PM2.5** .
- Four Tennessee counties (**Anderson, Blount, Knox, Shelby) do not meet** (or contribute to air quality in a nearby area that does not meet) **national air quality standards** for ground-level **ozone.**
- In Tennessee**, energy production and consumption is responsible for 37 and 41 percent of emissions that contribute to PM2.5 and ground-level ozone.**
- The **vast majority of CO_2** (a prevalent greenhouse gas) emissions in the state **originate from transporting people and goods and from power plants.** Over 96 percent of CO_2 emitted from power plants in Tennessee originates from one of TVA's coal-fired power

plants. TVA's Cumberland and Gallatin plants rank 13th and 96th in CO_2 emissions nationwide.

- The **vast majority of energy-related methane** (a potent greenhouse gas) emissions in the state **originate from the production, processing, transmissions, storage, and distribution of petroleum and natural gas.**

Energy-Related Pollution and Emissions

The production and consumption of fossil fuels results in emissions of air and water pollutants that threaten human health, harm wildlife, and deteriorate natural landscapes. These pollutants differ in terms of their geographic scope (regional impacts versus global impacts), health impacts, and sources of emission (power plants, vehicles, industry). In addition to having direct impacts to human health and the environment, some pollutants interact in the atmosphere to create new harmful pollutants. For example, ground level ozone is created by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOC).[178]

Regional (Criteria) Air Pollutants

The Clean Air Act requires the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment.[179] The "criteria" pollutants are regional in scale in that the health of Tennesseans is negatively impacted by energy use within the state. EPA monitors emissions of these pollutants as part of the National Emissions Inventory. EPA has set NAAQS for six principal criteria pollutants.[180]

Particulate matter: The U.S. EPA defines particulate matter (PM) as "a mixture of solid particles and liquid droplets found in the air." Some PM can be observed with the human eye but much of it is so small that it can only be observed with an electron microscope. Smaller PM is a concern because these particulates can penetrate more deeply into the lungs and has been linked to adverse health impacts such as aggravated asthma, lung disease, and heart attacks. PM is generally divided into two size classes:

PM10 – emissions that are less than 10 microns in diameter. Typical sources for PM10 include crushing and grinding operations and dust from road paving.

[178] http://www.epa.gov/groundlevelozone/basic.html Accessed December, 4, 2014.
[179] http://www.epa.gov/air/criteria.html Accessed October 12, 2014.
[180] http://www.epa.gov/airquality/urbanair/ Accessed October 12, 2014.

PM2.5 – emissions that are less than 2.5 microns in diameter. Typical sources for PM2.5 include motor vehicles, fossil-fuel power plants, certain industrial processes, and wood-burning.

PM2.5 is a great concern to the health of Tennesseans. Primary health impacts of PM2.5 include premature death in people with heart or lung disease; heart attacks; aggravated asthma; and decreased lung function. County-level PM2.5 emissions in tons per square mile in 2011 are presented in Figure 6.1. The countries with the highest concentration of particulate emissions tend to be near Tennessee's four largest metropolitan areas and near one of TVA's coal-fired power plants.

Figure 6.1. PM2.5 Emissions in 2011 (Tons per Square Mile)
Source: EPA National Emissions Inventory (http://www.epa.gov/air/emissions/index.htm)

Ground level ozone: Ozone is found in in the upper regions of the atmosphere and at ground level. Both types of ozone have the same chemical composition (O_3). While upper atmospheric ozone protects the earth from the sun's harmful rays, ground-level ozone (what we breathe) can harm our health. Even relatively low levels of ozone can cause health effects. People with lung disease, children, older adults, and people who are active outdoors may be particularly sensitive to ozone. Ozone also affects sensitive vegetation and ecosystems, including forests, parks, wildlife refuges and wilderness areas. In particular, ozone harms sensitive vegetation, including trees and plants during the growing season.

Ground level ozone is not emitted directly into the air, but is created by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOC). Ozone is likely to reach unhealthy levels on hot sunny days in urban environments. Ozone can also be transported long distances by wind. For this reason, even rural areas can experience high ozone levels. Over 75 percent of VOC emissions in Tennessee originate from vegetation and soil due to a process known as biogenics. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major anthropogenic sources of NOx and VOC. County-level VOC emissions in tons per square mile in 2011 are presented in Figure 6.2.

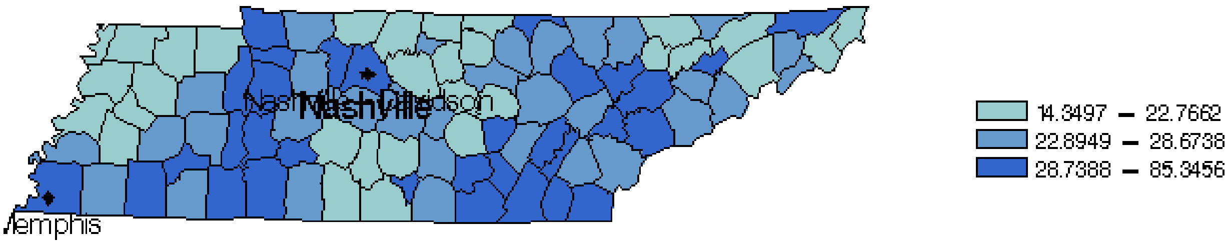

Figure 6.2. VOCs Emissions in 2011 (Tons per Square Mile)
Source: EPA National Emissions Inventory ([http://www.epa.gov/air/emissions/index.htm)](http://www.epa.gov/air/emissions/index.htm)

Sulfur dioxide: Sulfur dioxide (SO_2) is one of a group of highly reactive gasses known as oxides of sulfur. The largest sources of SO_2 emissions across the U.S. are from fossil fuel combustion at power plants (73 percent) and industrial facilities (20 percent). Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore, and the burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment. SO_2 is linked to a number of adverse effects including bronchoconstriction and increased asthma symptoms. County-level SO_2 emissions in tons per square mile in 2011 are presented in Figure 6.3.

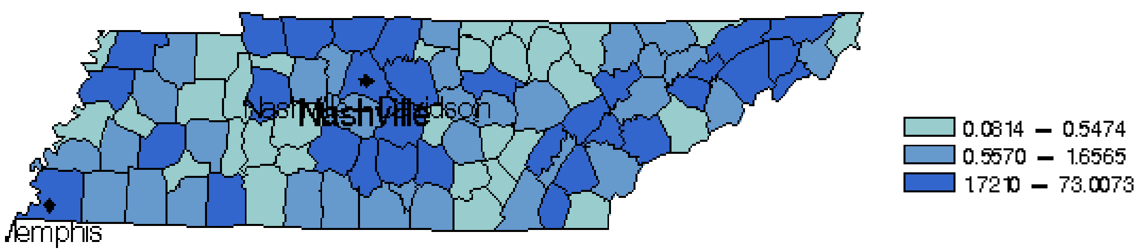

Figure 6.3. Sulfur Dioxide Emissions in 2011 (Tons per Square Mile)
Source: EPA National Emissions Inventory ([http://www.epa.gov/air/emissions/index.htm)](http://www.epa.gov/air/emissions/index.htm)

Nitrogen Oxides: EPA's National Ambient Air Quality Standard uses NO_2 as the indicator for the larger group of nitrogen oxides that include nitrous acid and nitric acid. NO_2 is linked with a number of adverse effects on the respiratory system. Primary health impacts include impaired lung function and increased respiratory infections in young children; eye, nose, and throat irritation. NO_2 also contributes to the formation of ground-level ozone (see below). NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and non-road equipment (lawn mowers, fork lifts, compressors, generators). All areas in the U.S. presently meet the current (1971) NO_2 NAAQS, with annual NO_2 concentrations measured at area-wide monitors well below the level of the standard. NO_2 concentrations should continue to decrease in the future as a result of a number of automobile emission standards that are taking effect. County-level NO_2 emissions in tons per square mile in 2011 are presented in Figure 6.4.

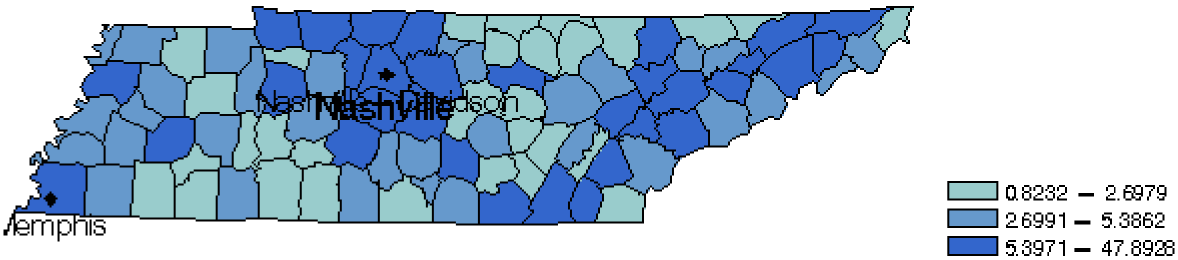

Figure 6.4. Nitrogen Oxide Emissions in 2011 (Tons per Square Mile)
Source: EPA National Emissions Inventory (http://www.epa.gov/air/emissions/index.htm)

Lead: Lead is a metal found naturally in the environment as well as in manufactured products. Exposure may occur through the air, ingestion of lead in drinking water and lead-contaminated food as well as incidental ingestion of lead-contaminated soil and dust. Lead can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system. The lead effects most commonly encountered in current populations are neurological effects in children and cardiovascular effects (e.g., high blood pressure and heart disease) in adults. Infants and young children are especially sensitive to even low levels of lead, which may contribute to behavioral problems, learning deficits and lowered IQ. The major sources of lead emissions have historically been from fuels in cars and trucks and industrial sources. Regulatory efforts to remove lead from motor vehicle gasoline decreased lead in the air by 94 percent between 1980 and 1999. Lead emissions in 2011 can be found in Figure 6.5 below.

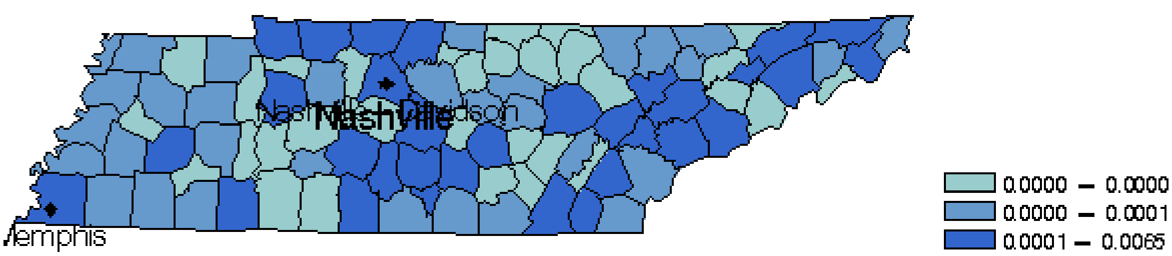

Figure 6.5. Lead Emissions in 2011 (Tons per Square Mile)
Source: EPA National Emissions Inventory (http://www.epa.gov/air/emissions/index.htm)

Carbon Monoxide: Carbon monoxide (CO) is a colorless, odorless gas emitted from combustion processes. Nationally and particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources. Everywhere in the country has air quality that meets the current CO standards due largely to improvements in motor vehicle emissions controls. Primary impacts include fatigue or chest pain; impaired vision and coordination; headaches; dizziness; confusion; and fatality at very high concentrations. County-level CO emissions in tons per square mile in 2011 are presented in Figure 6.6.

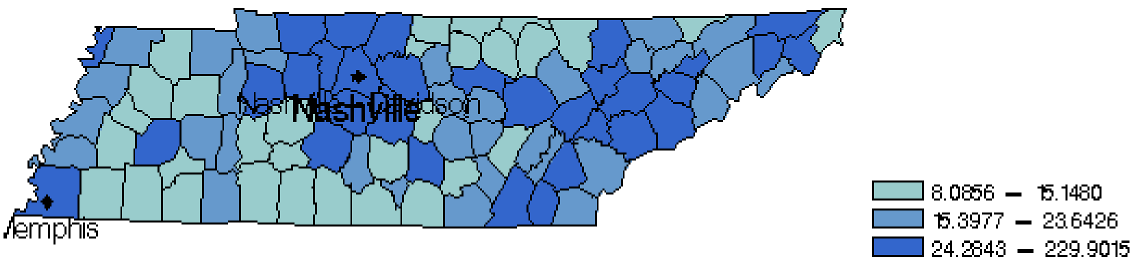

Figure 6.6. Carbon Monoxide Emission in 2011 (Tons per Square Mile)
Source: EPA National Emissions Inventory (http://www.epa.gov/air/emissions/index.htm)

Each criteria pollutant has at least one NAAQS standard. These standards are based on medical studies that indicate "safe" levels of pollutants where risk associated with exposure is very low. The concentration of some air pollutants (for example particulate matter) can change drastically over time necessitating a 24-hour and annual requirement to capture long-term exposure to pollutants and day-to-day changes in pollution. EPA defines a nonattainment area as "any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant." Table 6.1 shows EPA nonattainment areas in Tennessee. Eight counties are considered in nonattainment with the majority of these counties failing to meet NAAQS standards for PM2.5.

Table 6.1. EPA Nonattainment Areas in Tennessee as of July 2014

Pollutant (Year of Standard)	NAAQS Standard	Counties in Nonattainment	Classification Standard
PM2.5 (1997)	**24-hour**: 98th percentile averaged over 3 years shall not exceed 65 micrograms per cubic meter of air; **Annual:** annual arithmetic mean averaged over 3 years shall not exceed 15 micrograms per cubic meter of air	Anderson, Blount, Hamilton, Knox, Loudon, Roane	Moderate
PM2.5 (2006)	**24-hour**: 98th percentile averaged over 3 years shall not exceed 35 micrograms per cubic meter of air; **Annual:** annual arithmetic mean averaged over 3 years shall not exceed 15 micrograms per cubic meter of air	Anderson, Blount, Knox, Loudon, Roane	Moderate
8-Hr Ozone (2008)	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years shall not exceed 0.075 parts per million	Anderson, Blount, Knox, Shelby	Marginal
Sulfur Dioxide (2010)	the 3-year average of the 99th percentile of the yearly distribution of 1-hour daily maximum SO_2 concentrations shall not exceed 75 parts per billion	Sullivan	Nonattainment
Lead (2008)	Arithmetic mean averaged over a 3 month period shall not exceed 0.15 micrograms per cubic meter of air	Sullivan	Nonattainment

Source: EPA Green Book, Current Nonattainment Counties for All Criteria Pollutants as of July 2, 2014. http://www.epa.gov/oaqps001/greenbk/ancl.html Accessed September 28, 2014.

In terms of areas in nonattainment, Tennessee has the most problem controlling PM2.5. EPA defines PM2.5 to include both filterable and condensable emissions. Filterable emissions are emissions that exit the stack in either solid or liquid state and may also be referred to as "front half" emissions or non-condensable emissions. It is the solid portion that is captured in the front-half of the sampling apparatus, typically on a filter. In the European Union and the remainder of the world, PM requirements typically only include filterable emissions.

Air Quality in the Great Smoky Mountains National Park

The Great Smoky Mountains National Park is the most visited national park in the country and a source of pride for many Tennesseans. Unfortunately, air pollution generated outside the Smokies is negatively impacting scenic views, trees and other plants, high-elevation streams and fisheries, and even the health of park visitors. The Smokies have struggled for years with limited scenic views due to a whitish haze created by air pollutants. While visibility in natural conditions can reach 93 miles, visibility in the park was often less than one mile a decade ago. A recent study by Colorado State University has documented a major reduction in particle pollution in the park leading to and drastic increase in visibility. However, ozone and nitrates continue to pose problems for the natural resources in the Smokies. Ozone exposures in the park are among the highest in the eastern U.S. On average, ozone levels over the ridgetops of the park are up to two times higher than Knoxville and Atlanta. Nitrate levels in some streams are approaching the public health standard for drinking water.

Source: National Park Service Briefing State, Air Quality Issues in the Great Smoky Mountains National Park (http://www.nps.gov/grsm/naturescience/air-quality.htm) and Cooperative Institute for Research in the Atmosphere, Colorado State University (http://www.cira.colostate.edu/)

To **achieve EPA's NAAQS air quality standard and improve air quality in Tennessee** in general, the **state must focus on reducing emissions of PM2.5, SO_2, VOC (contributor to ozone), and lead.** However, these pollutants can be transported by wind currents far from where they were emitted. This limits Tennessee's ability to improve air quality in the state since the state's air quality will be influenced by pollutants blowing in from outside the state. EPA's Cross-State Air Pollution Rule was designed to address this issue. This rule has been in development since 2008. The rule was challenged but upheld by the U.S. Supreme Court in April 2014.

Emissions of these four pollutants come from very different sources – energy production and consumption, transportation, industrial processes, and natural processes. Table 6.2 shows the top three sources of these pollutants and the percentage of these emissions that are due to energy production or consumption in Tennessee and the U.S. Vehicle emissions from the combustion of fossil fuels are primary sources of nitrogen oxides, VOCs, lead, and carbon monoxide. Fossil fuel combustion from industrial sources and power plants are primary contributors of PM2.5, nitrous oxides, and sulfur dioxide.

Table 6.2. Sources of Regional Criteria Pollution in 2012

Pollutant	Top 3 US sources	Percent of US emissions from energy categories†	Top 3 TN sources	Percent of TN emissions from energy categories†
PM2.5	1) misc. 2) fuel combustion–other 3) industrial processes	20.2	1) misc. 2) fuel combustion–industrial, 3) industrial processes	36.9
VOC	1) misc. 2) solvent utilization 3) petroleum and related industries	42.3	1) solvent utilization 2) highway vehicles 3) off-highway	41.0
Sulfur dioxide (SO_2)	1) fuel combustion – electric utilities 2) fuel combustion – industry 3) fuel combustion -other	89.3	1) fuel combustion – electric utilities 2) fuel combustion – industry 3) fuel combustion -other	97.5
Nitrogen oxides (NOx)	1) highway vehicles 2) off-highway engines 3) fuel combustion – electric utilities	93.1	1) highway vehicles 2) off-highway engines 3) fuel combustion - industrial	95.6
Lead	1) highway vehicles 2) off highway engines 3) industrial processes	69.8	1) industrial processes 2) highway vehicles 3) off highway engines	50.0
Carbon Monoxide (CO)	1) highway vehicles 2) misc. 3) off-highway engines	62.2	1) highway vehicles 2) off-highway engines 3) misc.	84.0
†Energy emission categories include fuel combustion – electric utilities; fuel combustion – industrial; fuel combustion – other; petroleum and related industries; highway vehicles; off-highway engines				

Source: EPA National Emissions Inventory (http://www.epa.gov/ttnchie1/trends/) Accessed September 14, 2014

Table 6.3 shows the generation capacity and current or planned emission control technologies at TVA power plants in the state. All plants have some form of emission control technology in place. These technologies have been especially effective at reducing sulfur dioxide and nitrogen oxide emissions in Tennessee. Selective catalytic reduction systems and low-NOx burners can reduce nitrogen oxide emissions by about 90 percent. Wet limestone scrubbers can remove 95 percent of sulfur dioxide from plant emissions.

Table 6.3. Generation Capacity and Emission Control Technologies at TVA Facilities

Plant Name	Location	Plant Type	Net MW Capacity	Emission Control Technologies
Cumberland	Middle Tennessee	Coal	2,386	1) selective catalytic reduction systems 2) wet limestone scrubbers 3) low-NOx burners
Gallatin	Middle Tennessee	Coal	976	To be installed by December 2017 1) selective catalytic reduction systems 2) scrubbers 3) low-NOx burners
John Sevier	East Tennessee	Coal	704	All Units will be retired by December 2015
John Sevier Combined Cycle Plant	East Tennessee	Natural Gas	880[181]	1) selective catalytic reduction systems 2) low-NOx burners
Johnsonville	Middle Tennessee	Coal	1206[182]	1) selective non-catalytic reduction systems 2) low-NOx burners
		Natural Gas or Fuel Oil	1128	
Kingston	East Tennessee	Coal	1398	1) selective catalytic reduction systems 2) scrubbers 3) low-NOx burners
Lagoon Creek	West Tennessee	Natural Gas or Fuel Oil	1140[183]	1) selective catalytic reduction systems 2) low NOx burners
Allen	West Tennessee	Coal	702[184]	1) selective catalytic reduction systems
Bull Run	East Tennessee	Coal	870	1) selective catalytic reduction systems 2) scrubbers

Source: TVA http://www.tva.com/power/fossil.htm Accessed October 7, 2014.

[181] Simple cycle combustion at 490 MW.
[182] All coal-fired units at Johnsonville will be retired by 2017.
[183] 12 simple cycle combustion at 904 MW; 2 combined cycle at 540 MW; total 1140.
[184] All coal-fired units at Allen will be retired by 2019; TVA will replace the plant with a 1,000 megawatt natural gas plant expected to cost $975 million.

TVA's Clean Air Act Agreement

In 2013, TVA approved agreements with the U.S. EPA, four states (Alabama, Kentucky, North Carolina, and Tennessee), and three environmental advocacy groups to resolve long-running disputes about how the Clean Air Act applies to routine maintenance and equipment replacement at TVA fossil plants. Consistent with the agreement, TVA plans to retire two coal-fired units at John Sevier, six units at Widows Creek in northern Alabama, and all 10 units at Johnsonville. TVA also announced plans to idle two units at John Sevier. The retirements, including the 1,000 megawatts of coal-fired capacity previously slated for idling, will eliminate 2,700 megawatts of coal-fired capacity by the end of 2017. This lost capacity will be replaced by low-emission of zero-emission electricity sources, including renewable energy, natural gas, nuclear power and energy efficiency. TVA will also provide $350 million in funding for environmental improvement projects over the next five years. Under the agreement, TVA is absolved of liability for past work at its plants but agreed to pay a $10 million civil penalty.

Source: http://www.tva.com/news/keytopics/cleanairagreement.htm Accessed December 4, 2014

Greenhouse Gases

Greenhouse gases (GHGs) are gases that trap heat in the atmosphere. Many of these gases such as carbon dioxide, methane, and nitrous oxide naturally occur in the atmosphere. Energy production and consumption produce additional human-caused emissions of many of these gases which elevate concentrations higher than naturally observed. These higher-than-natural concentrations of greenhouse gases raise concerns over climate change.

Unlike regional *criteria pollutants* which cause impacts to human health and the environment in the vicinity of the emission source, GHGs have global impacts irrespective of where they are emitted. Thus, impacts from GHG experienced in Tennessee will be due to emissions of these pollutants across the globe. Likewise, emitting GHG in Tennessee will have impacts across the globe. Human production of GHG can be categorized as stationary sources and non-stationary sources. Stationary sources include electricity generation plants, industrial facilities, mine and drill sites, and residences that burn fossil fuels. Non-stationary sources include vehicles and fires.

Figure 6.7 shows the mix of GHG emissions in 2012. Carbon dioxide is by far the most abundant. But it is also important to note that GHGs are not all equally as effective at trapping heat in the atmosphere. The two most important characteristics of a GHG in terms of climate impact are:

How well the gas prevents energy from immediately escaping to space

How long the gas stays in the atmosphere

The Global Warming Potential (GWP) for a gas is a measure of the total energy that a gas absorbs over a particular period of time (usually 100 years), compared to carbon dioxide. The larger the GWP, the more warming the gas causes. Carbon dioxide has a GWP of 1 and serves as a baseline for other GWP values. Methane (CH_4) has a GWP more than 20 times higher than CO_2 for a 100-year time scale. Nitrous Oxide (N_2O) has a GWP 300 times that of CO_2 for a 100-year timescale.

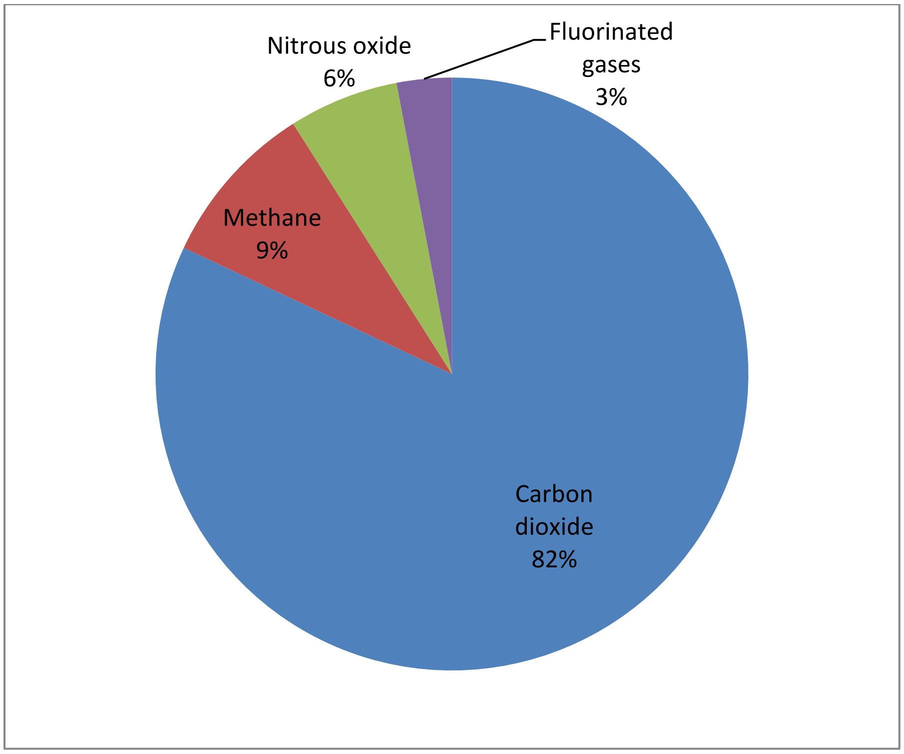

Figure 6.7. 2012 U.S. Greenhouse Gas Emissions
Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 (http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html)

Two datasets are used to capture a snapshot of GHG emissions in Tennessee.[185] EPA Facility Level Information on GHGs Tool (FLIGHT) provides annual emissions from large facilities in the state. These large facilities represent stationary sources of GHGs and are broken into four types:

1. Petroleum and Natural Gas Systems

[185] Combining these two sources provides a few benefits over other measures of GHG emissions. First, all the GHG emission estimates reported are from EPA sources. EPA is charged with the regulation of GHG emissions providing a regulatory incentive to view Tennessee's contribution to GHG emissions from EPA's perspective. Second, the GHG emissions from stationary sources are reported by the facility which alleviates the need to make generalizations about technology across industries. Third, these datasets provide more detail about emitting sectors of the economy that may be specific to Tennessee. EIA also provides greenhouse gas emissions for the state of Tennessee. These estimates are based on energy consumption in each sector of the economy and an average amount of GHG emissions per unit of energy consumed.

2. Power Plant
3. Refineries
4. Industrial Fossil Fuel Combustion

There are a variety of industries that emit GHGs in Tennessee. Table 6.4 shows industrial categories responsible for GHG emissions in Tennessee. These industries may be emitting GHG due to fossil fuel combustion (an energy-related emission) or industrial processes unrelated to fossil fuels (cement manufacturing). To capture non-stationary sources of GHG emissions we utilize the EPA National Emissions Inventory which provides estimates of GHG emissions from prescribed fires, wildfires, on-road vehicles, and non-road equipment (lawn mowers, generators, and compressors).

Table 6.4. Tennessee Industries Responsible for GHG Emissions in 2012

NAICS Code	Industry Description
928110	National Security
326211	Tire manufacturing
311612	Meat Processed from Carcasses
311221	Wet corn milling
311422	Specialty Canning
313230	Nonwoven Fabric Mills
325193	Ethyl Alcohol Manufacturing
311613	Rendering and Meat Byproduct Processing
325920	Explosives Manufacturing
325211	Plastics Material and Resin Manufacturing
311230	Breakfast Cereal Manufacturing
611310	Colleges, Universities and Technical Schools
336111	Automobile Manufacturing
311919	Other Snack Food Manufacturing
311222	Soybean Processing
311423	Dried and Dehydrated Food Manufacturing
311615	Poultry Processing
541712	Research and Development in Physical, Engineering, and Life Sciences
332999	Miscellaneous Fabricated Metal Product Manufacturing
326121	Unlaminated Plastics Profile Shape Manufacturing

Source: EPA Facility Level Information on GHGs Tool (FLIGHT) (http://ghgdata.epa.gov/ghgp/main.do)

Energy production and consumption is a primary source of emissions for three GHGs.[186]

[186] Fluorinated gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) are another category of greenhouse gases. These gases are produced primarily from industrial processes.

Carbon dioxide (CO_2)

In 2012, CO_2 accounted for about 82 percent of all U.S. GHG emissions from human activities. Carbon dioxide is naturally present in the atmosphere as part of the carbon cycle (the natural circulation of carbon among the atmosphere, oceans, soil, plants, and animals). Human activities alter the carbon cycle by adding more CO_2 to the atmosphere and by influencing the ability of natural features, like forests, to remove CO_2 from the atmosphere – carbon sequestration.

Figure 6.8 shows U.S. carbon dioxide emissions by source. The combustion of fossil fuels to generate electricity is the largest single source of CO_2 emissions in the nation, accounting for about 39 percent of total U.S. CO_2 emissions and 31 percent of total U.S. greenhouse gas emissions in 2012. To produce a given amount of electricity, burning coal will produce more CO_2 than oil or natural gas. Certain energy-related processes (for example many clean coal technologies) seek to minimize contributions of CO_2 through carbon sequestration. The combustion of fossil fuels such as gasoline and diesel to transport people and goods is the second largest source of CO_2 emissions, accounting for about 32 percent of total U.S. CO_2 emissions and 27 percent of total U.S. greenhouse gas emissions in 2012. Industrial processes such as cement manufacturing and steel production may also produce carbon dioxide emissions in the absence of fossil fuel combustion.

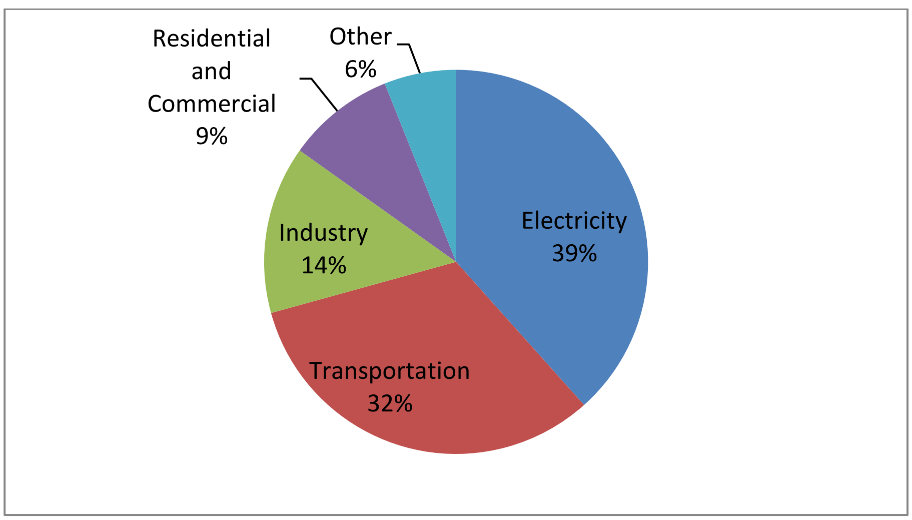

Figure 6.8. 2012 U.S. Carbon Dioxide Emissions by Source
Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 (http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html)

Figure 6.9 shows the source of CO_2 emissions in Tennessee. The vast majority of CO_2 emissions in the state originate from transporting people and goods and power plants. Over 60 percent of the CO_2 emissions in the transportation sector in Tennessee come from light duty cars and trucks.

Figure 6.10 shows CO_2 emissions in the power plant category by plant.[187] Over 96 percent of CO_2 emitted in the power plant category in Tennessee originates from one of TVA's coal-fired power plants. As of 2013, the Cumberland Plant in Stewart County is the largest CO_2 emitter at over 14 million metric tons followed by the Gallatin plant in Sumner County at over 6 million metric tons. By comparison, the largest single source of CO_2 in the country is the Scherer plant in Georgia at nearly 22 million metric tons. The Cumberland and Gallatin plants rank as the 13th and 96th largest emitter of CO_2 in the nation, respectively.

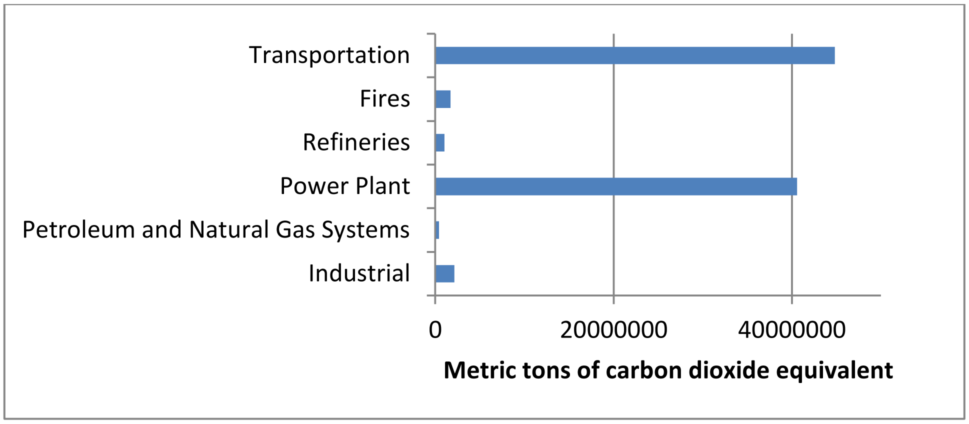

Figure 6.9. Tennessee Carbon Dioxide Emissions by Source, 2012
Source: EPA National Emissions Inventory (http://www.epa.gov/air/emissions/index.htm)
EPA Facility Level Information on GHGs Tool (FLIGHT) (http://ghgdata.epa.gov/ghgp/main.do)

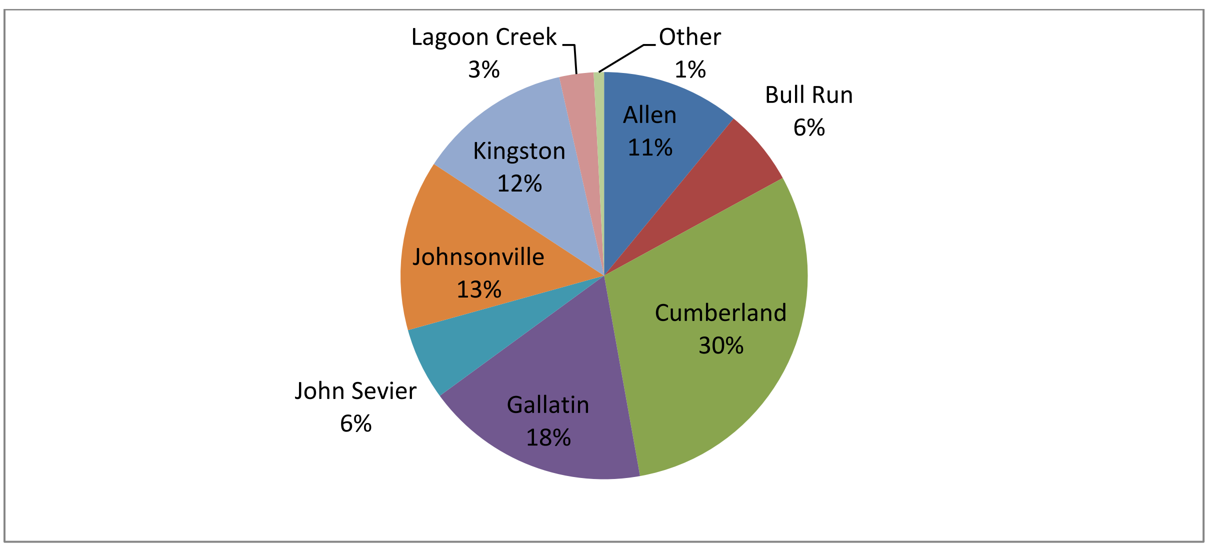

Figure 6.10. Tennessee Power Plant Emissions of Carbon Dioxide, 2012
Source: EPA Facility Level Information on GHGs Tool (FLIGHT) (http://ghgdata.epa.gov/ghgp/main.do)

[187] All coal-fired units at John Sevier will be retired by December 2015. All coal-fired units at Johnsonville will be retired by 2017. All coal-fired units at Allen will be retired by 2019.

EPA's Clean Power Plan

In March 2012, EPA proposed a rule limiting carbon dioxide emissions from *new* fossil fuel-fired power plants. In light of public comments and other information, EPA withdrew the proposed rule in 2013 and proposed a revised rule that is not yet final. In June 2014, the EPA proposed a rule to limit carbon dioxide emissions from *existing* fossil-fuel fired power plants in the U.S. The motivation for this rule is based on estimates of the economic damages associated with CO_2 emissions (the social cost of carbon). The proposed rule, called the "Clean Power Plan," sets out a framework for states to regulate carbon emissions from existing coal-fired, oil-fired, and natural gas-fired power plants. In the Clean Power Plan, EPA has proposed a 39% reduction goal for Tennessee. Most of the coal-fired plants scheduled by TVA for continued operation are in Tennessee. While there are many different strategies the state may adopt to achieve this goal, all strategies will have to address emissions from coal-fired power plants.

Sources:
Mary English. 2014. "The Clean Power Plan: Regulating Carbon Dioxide Emissions from Existing Power Plants" Policy Brief 2.14, The Howard H. Baker Jr. Center for Public Policy, University of Tennessee. *http://bakercenter.utk.edu/2014/08/25/the-clean-power-plan-policy-brief-by-dr-mary-english/*.
Charles Sims. 2014. "What Are the Benefits of Federal Carbon Policies and How Well Do We Know Them?" Policy Brief 3.14, The Howard H. Baker Jr. Center for Public Policy, University of Tennessee. *http://bakercenter.utk.edu/2014/08/25/dr-charles-sims-releases-policy-brief-on-carbon-reduction-policies/*.

Methane (CH_4)

In 2012, methane accounted for about 9 percent of all U.S. GHG emissions. While human-caused emissions of methane are far lower than carbon dioxide, methane is a far more potent greenhouse gas. Based on GWP, methane is more than 20 times more effective at trapping heat. Natural processes in the soil and chemical processes in the atmosphere help remove methane.

Figure 6.11 shows U.S. methane emissions by source. Methane is emitted from natural sources such as wetlands. These natural emissions account for over 60 percent of U.S. methane emissions. It is also emitted during production and transport of coal, natural gas, and oil. For example, in addition to being a GHG, methane is also the primary component of natural gas. Fugitive emissions of methane arise due to natural gas flaring at the well site or escaped gas during transport and pumping. These types of fugitive emissions account for nearly 30 percent of methane emissions nationwide. Other human activities that lead to methane emissions are livestock and other agricultural practices and the decay of organic waste in landfills. Methane produced by landfills is currently being captured and utilized to generate electricity by WM Renewable Energy, LLC in Knox (Chestnut Ridge Gas Recovery) and Benton (West Camden) Counties.

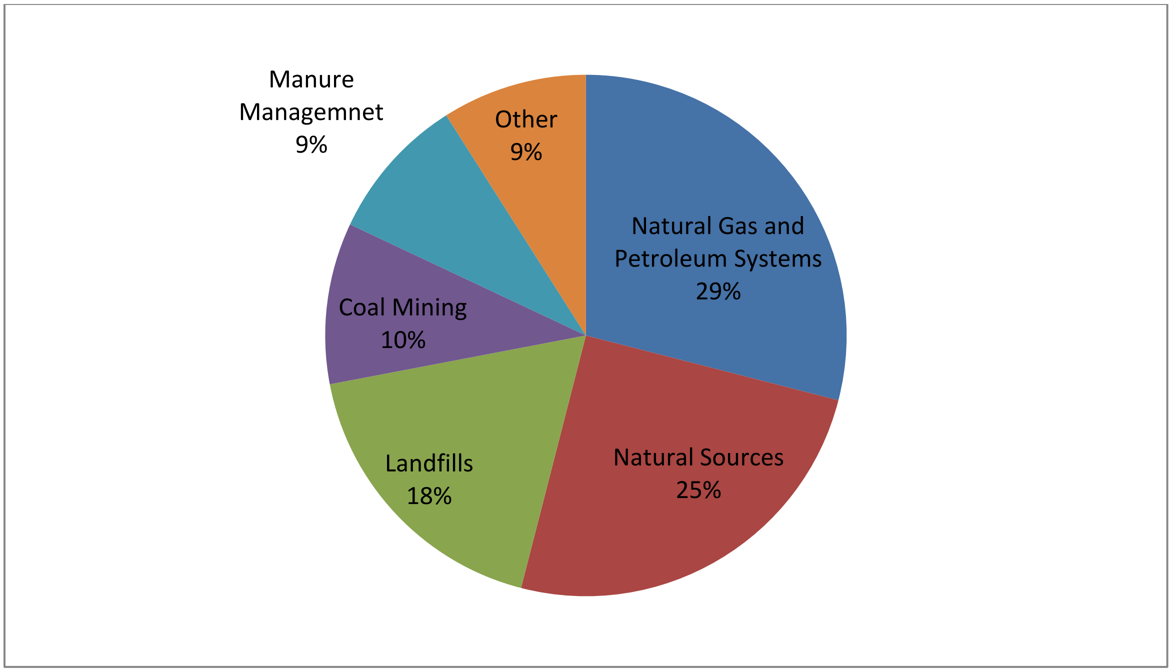

Figure 6.11. 2012 U.S. Methane Emissions by Source
Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 (http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html)

Figure 6.12 shows energy-related sources of methane emissions in Tennessee. The largest producers of methane in the state are municipal and industrial waste landfills. However, the vast majority of energy-related methane emissions in the state originate from the petroleum and natural gas system which includes:

- Production and Processing
- Drilling and well completion
- Producing wells
- Gathering and boosting
- Gas processing plant
- Natural Gas Transmission and Storage
- Transmission and compressor stations
- Underground storage
- LNG storage
- LNG import-export equipment
- Distribution
- Distribution mains/services
- Regulators and meters

Over 67 percent of methane emissions in the petroleum and natural gas system in the state are due to compressor stations. The largest methane emitter in this category is Texas Gas Transmission's Kenton Compressor Station in Gibson County with over 35,000 metric tons of methane. By comparison, the largest emitter of methane in the state is the South Shelby Landfill at 293,130 metric tons. The remainder of the methane emissions in the state is attributable to municipal gas utilities. Of these utilities, Memphis Light, Gas, and Water produce the most methane at 30,725 metric tons.

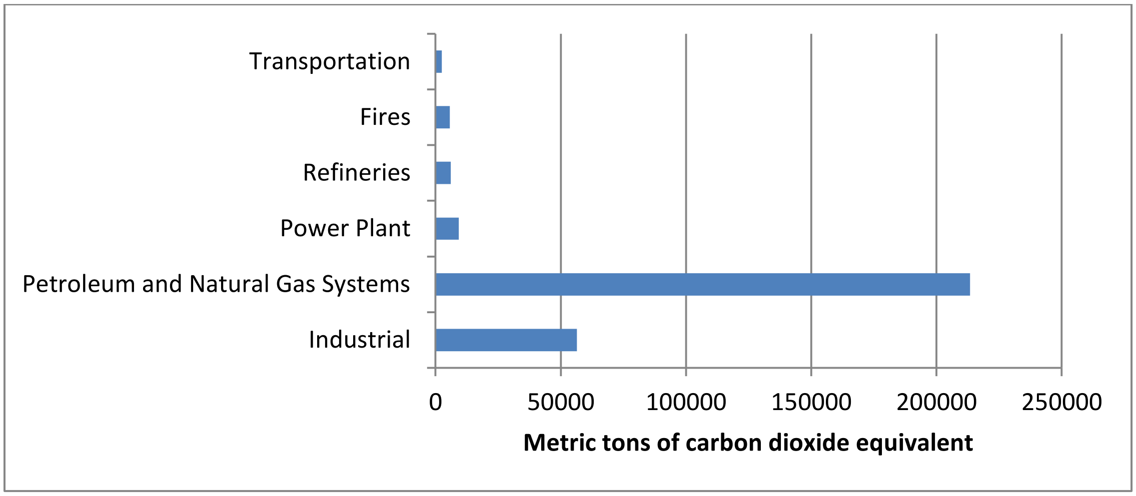

Figure 6.12. Tennessee Methane Emissions by Source, 2012
Source: EPA National Emissions Inventory (http://www.epa.gov/air/emissions/index.htm) and EPA Facility Level Information on GHGs Tool (FLIGHT) (http://ghgdata.epa.gov/ghgp/main.do)

While energy related methane emissions currently represent a relatively small portion of total methane emissions in the state, there is a rising concern that natural gas exploration and development could make this a more substantial contribution in the near future.

Nitrous oxides (N_20)

In 2012, N_20 accounted for about 6 percent of all U.S. GHG emissions from human activities. While human-caused emissions of N_20 are far lower than carbon dioxide, N_2O is a far more potent GHG. Based on GWP, The impact of 1 pound of N_2O on warming in the atmosphere is over 300 times that of 1 pound of carbon dioxide.

Figure 6.13 shows U.S. nitrous oxide emissions by source. Nitrous oxide is naturally present in the atmosphere as part of the nitrogen cycle. Globally about 60 percent of total nitrous oxide emissions come from natural sources. Human activities such as agriculture (soil and manure management), fossil fuel and solid waste combustion, and industrial activities also emit nitrous oxide. The largest human contributor of N_2O is agricultural soil management and specifically synthetic fertilizer application. Fossil fuel combustion from stationary sources and the transportation sector is a distant second in terms of nationwide N_2O emissions.

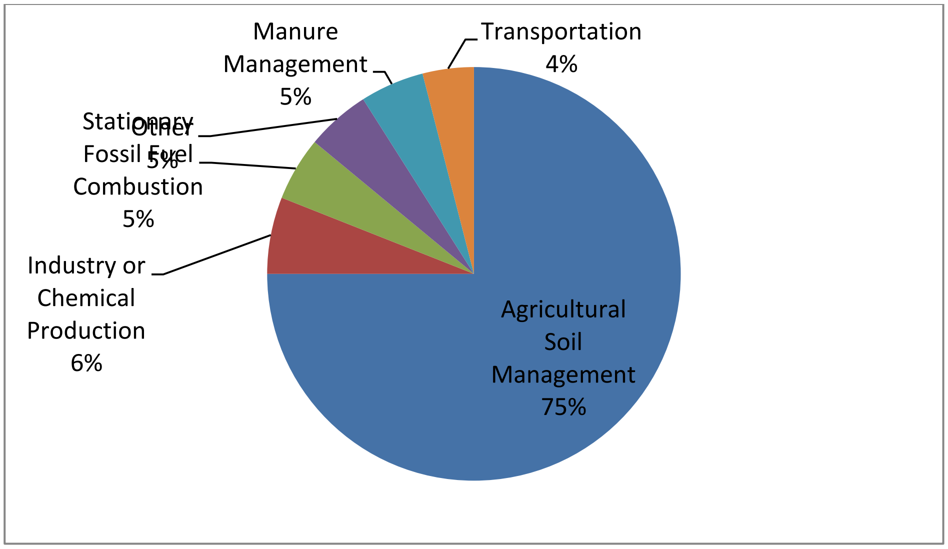

Figure 6.13. 2012 U.S. Nitrous Oxide Emissions by Source
Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 (http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html)

Power plants in Tennessee emitted 206,806 metric tons of nitrous oxide in 2012 - by far the largest contributor in the state. Figure 6.14 shows N_2O emissions in the power plant category by plant.[188] As of 2013, the Cumberland Plant in Stewart County is the largest N_20 emitter at 74,879 metric tons followed by the Gallatin plant in Sumner County at 34,207 metric tons. By comparison, the largest single source of N_2O in the country is Ascend Performance Material LLC in Florida at over 5 million metric tons. The Cumberland and Gallatin plants rank as the 39th and 119th largest direct emitter of N_20 in the nation, respectively.

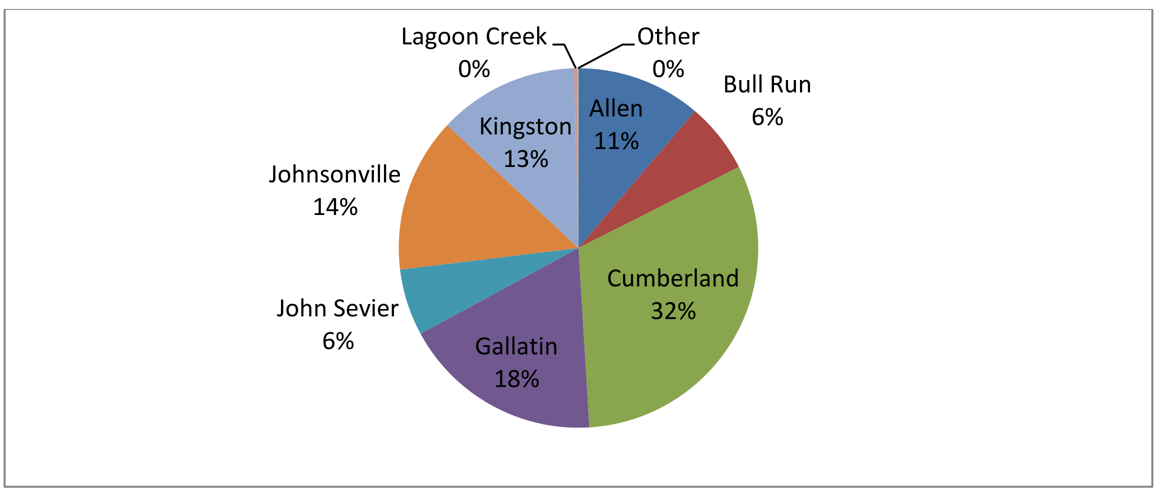

Figure 6.14. Tennessee Power Plant Emissions of Nitrous Oxide, 2012
Source: EPA Facility Level Information on GHGs Tool (FLIGHT) (http://ghgdata.epa.gov/ghgp/main.do)

[188] All coal-fired units at John Sevier will be retired by December 2015. All coal-fired units at Johnsonville will be retired by 2017. All coal-fired units at Allen will be retired by 2019.

Legacy Costs of Fossil Fuel Extraction

When operators choose to terminate production at coal mines and oil/gas wells, they are required by federal and state law to alleviate the environmental and health impacts at these sites. Alleviating the impacts at mining and drilling sites that are no longer in operation is known as reclamation and the lack of full reclamation poses a risk to water quality, human health, and safety. To incentivize reclamation, the state of Tennessee collects a performance bond from operators before issuing mining and drilling permits. Once full reclamation is complete, the bond is returned to the operator.

If full reclamation is not complete, these bonds are forfeited and used to fund reclamation projects. These projects generally require earthmoving and re-vegetation and the bonds collected are generally insufficient to pay for full reclamation.

Coal Mining

Abandoned coal mines pose serious threats to public health and safety as well as degrade the environment. The 1977 Surface Mining Control and Reclamation Act (SMCRA) requires that coal mines be reclaimed and not cause water pollution for an indefinite period of time. The Land Reclamation Section within TDEC's Division of Water Resources administers three different reclamation programs:

Federal program – monies from the Abandoned Mine Reclamation Fund and limited to only high priority (health and safety) AML problems. The Abandoned Mine Reclamation Fund, established as part of SMCRA, is the primary funding mechanism used to reclaim abandoned mine land (AML) sites. This fund is generated by a federal per-ton tax on mined coal: $0.12 per ton for underground mined coal and $0.28 per ton for surface mined coal. These funds are then distributed to TDEC's Abandoned Mine Land Reclamation Program for reclamation projects. In 2013, Tennessee received $2.8 million from the Fund. Tennessee's Abandoned Mine Land Reclamation Program only reclaims the highest priority sites because (i) the Abandoned Mine Reclamation Fund is insufficient to reclaim all sites and (ii) the 2006 reauthorization of SMCRA restricts expenditure of monies from the federal fund to only high priority coal AML sites. Thus a coal AML site that has only environmental problems (deemed low priority) cannot be reclaimed with federal monies.

State Program – created in 1986 by the state legislature when Tennessee returned the Title V regulatory program back to OSMRE and lost federal AML funding. This program is funded through state appropriation. This program is currently unfunded due to Tennessee Division of Water Resources budget constraints.

Bond Program – reclamation on high priority coal and non-coal sites using monies from the Tennessee Surface Mining Reclamation Fund (bond fund).

The Land Reclamation Section is responsible for reclaiming:

Abandoned mine lands (AML) – mines that existed before SMCRA (1977) and required no bond

As of September 2014, there were 17,331 acres[189] (6,465 reclaimed acres and 10,568 unreclaimed acres) of abandoned mines in Tennessee scattered across 20 counties (see Figure 6.15).[190] Figure 6.16 presents the estimated cost of restoring unreclaimed mine sites and the actual federal program completed costs of sites already reclaimed with Abandoned Mine Reclamation Fund monies. Nearly $43 million has already been spent to reclaim 37 percent of these lands. The Office of Surface Mining Reclamation and Enforcement (OSMRE) estimates it will cost $44.4 million to reclaim the remaining 11,000 acres.

Bond forfeiture sites - reclamation was deemed inadequate

Mines post-SMCRA are required to post a performance bond before mining operations can begin. If mine operators fully reclaim the mine site after operations cease, the performance bond is refunded to the operator. Some operators choose to forfeit their performance bonds rather than continue to pay for reclamation. Bonds forfeited after November 5, 1990 are collected by OSMRE and they would be responsible for reclamation on those sites. Bonds forfeited prior to November 5, 1990 were collected by the state and TDEC would reclaim these sites if they posed a threat to public health and safety. Any bonds from non-coal sites would be collected and eligible for reclamation by TDEC under the Bond Program. The bonds associated with many of these sites were initially paid in the 1970's when mining operations began and is usually not sufficient to fully reclaim these sites. As a result, the Land Reclamation Section must assess the severity of the impacts and prioritize reclamation projects to those sites which exhibit the most severe impacts. Each year only the highest priority (most at risk) sites are reclaimed. The Knoxville Field Office of

[189] This number does not include the 154 sites (1,142 acres at a cost of $11.4 million) reclaimed by TDEC using state funding (discontinued in 2012), the bond fund, and the occasional matching dollars leveraged with state bond funds.

[190] Acre is defined according to the Government Performance and Results Act (GPRA). This definition is not a pure acreage total as it converts features like water lines and mine openings into an acreage amount. For example, based on this definition, each resident with polluted water from AML impacts is equal to 5 acres.

the OSMRE forfeited and collected the bond for three permanent program permits during FY 2012. Reclamation of all three sites (102 acres) was conducted in FY 2013.[191]

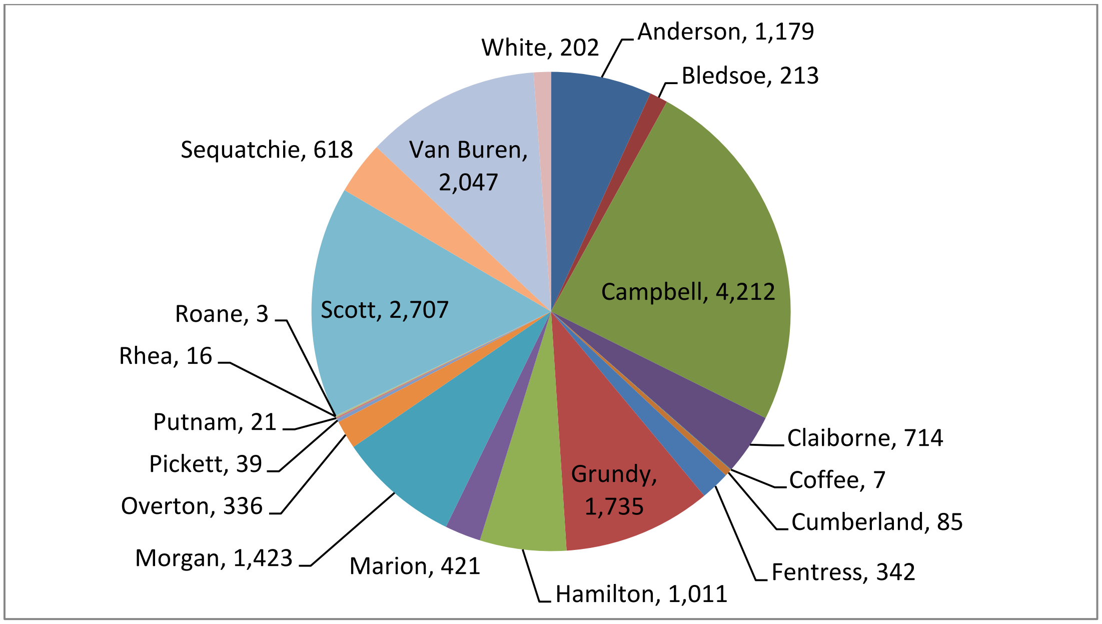

Figure 6.15. Total Abandoned Mine Acres by County

Source: Office of Surface Mining Reclamation and Enforcement, Abandoned Mine Land Inventory System

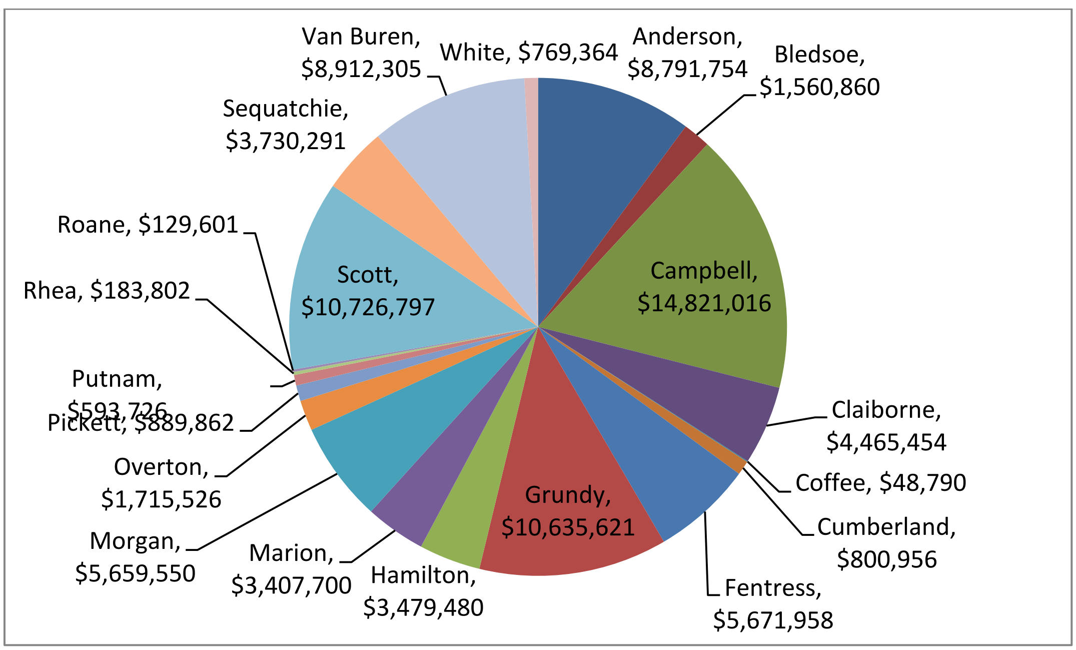

Figure 6.16. Reclamation Costs by County

Source: Office of Surface Mining Reclamation and Enforcement, Abandoned Mine Land Inventory System

[191] 2013 Evaluation Summary Report for the Regulatory Program Administered by the Knoxville Field Office of OSMRE (http://www.arcc.osmre.gov/about/states/tn.shtm).

Oil and Natural Gas Wells

Abandoned wells are defined as inactive with no responsible party to plug the well and restore the location. Many abandoned wells could cause injuries and property damage by spontaneously releasing pressurized and highly flammable fluids. Plugging the well prevents groundwater pollution and reclaiming the area can prevent leakage from above ground tanks and machinery. To incentivize well operators to plug and reclaim any abandoned well sites, oil and gas well operators in the state of Tennessee are required to post a reclamation bond of $1,500 per well site. A $2,000 single well plugging bond is required for wells drilled from 0 to 2500'. Wells drilled from 2501' to 5000' require a $3,000 single well plugging bond. Any well drilled deeper than 5000' will require an additional $1 per foot cost for single well plugging bonds.

Figure 6.17 shows the location of abandoned oil and gas wells in the state. As of 2013, TDEC reported 3,595 abandoned oil and gas wells in the state.[192] Fentress County had the largest number of abandoned gas wells followed by Overton County.

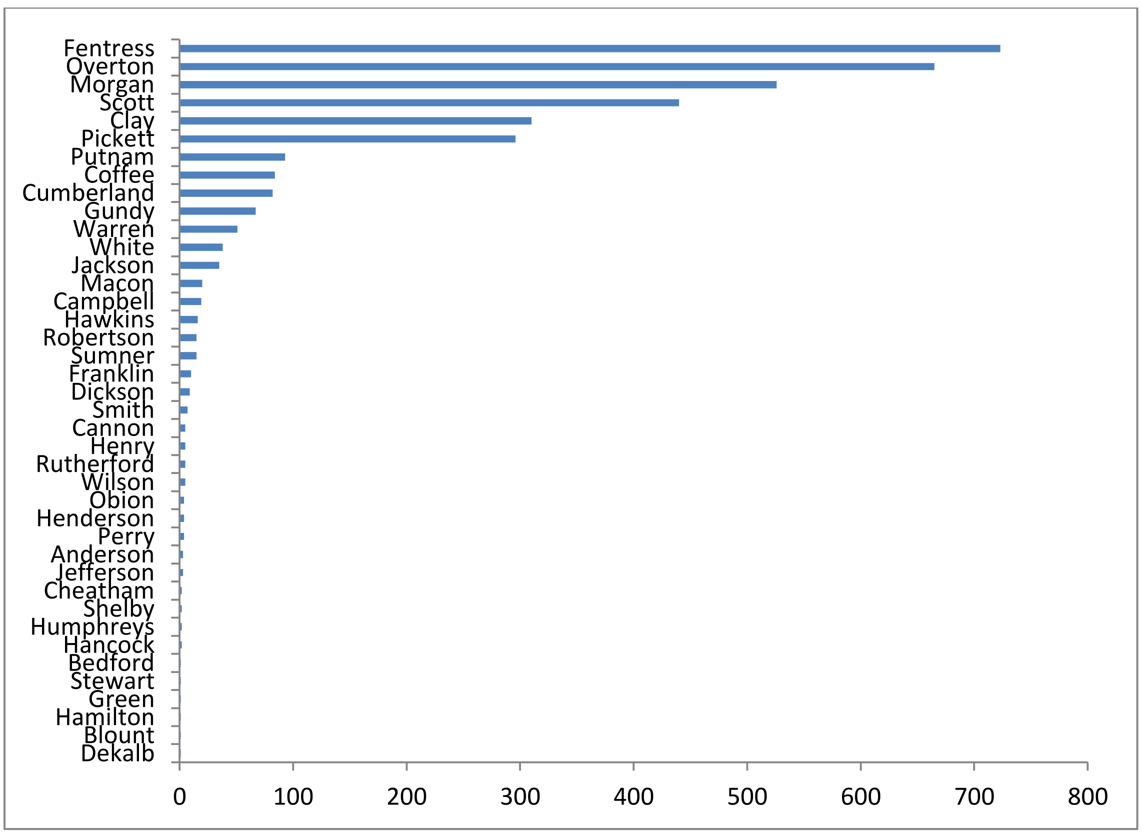

Figure 6.17. Abandoned Oil and Gas Wells by County
Source: Tennessee Department of Environment and Conservation

[192] This does not include wells that were plugged before being abandoned.

Health Impacts

Energy production and consumption in Tennessee create air and water pollution that negatively impacts the health of Tennesseans. Air pollutants such as PM2.5, nitrogen oxides, sulfur dioxides, and ground-level ozone have been linked to asthma, chronic obstructive pulmonary disease (COPD), heart attack, stroke, and lung cancer. Drawing precise linkages between pollution and health outcomes is a complex task for two reasons:

Many factors may contribute to the incidence of a health outcome. For example, in October 2013, the International Agency for Research on Cancer (IARC), part of the World Health Organization, classified outdoor air pollution as a cancer-causing agent. However, smoking is well understood to be a major contributor to lung cancer in the U.S. The best available science estimates that outdoor air pollution accounts for 1-2 percent of lung cancers.

Estimating health impacts requires that people are diagnosed. Incidence rates are commonly used to report the prevalence of a disease in a population. However, incidence rates are likely to under-report actual health impacts since many people will never be diagnosed. To address the problem with under-reporting, death rates are also used to ascertain health impacts. This is also problematic since it does not indicate how long people suffered from an ailment and many factors may contribute to death.

With these factors in mind, the following sections provide information on the incidence and death rates in Tennessee for health impacts related to energy production and consumption.

Asthma

Asthma is a chronic lung condition that causes airways in the respiratory system to be swollen and produce mucus. During an asthma attack, inflammation increases and the muscles surrounding the airways tighten. The combination of swelling, mucus, and tightening of the airways causes coughing, wheezing, and shortness of breath. Asthma is thought to be caused by a combination of genetic and environmental factors. Environmental factors include outdoor air pollution such as PM2.5, nitrogen oxides, sulfur dioxide, and ozone but also include allergens and environmental chemicals.

In 2010, 66 Tennesseans died due to an underlying diagnosis of asthma and there were 174 deaths for which asthma was listed as any cause of death. These asthma mortality rates declined between 2001 and 2010 and were similar to asthma mortality rates in other parts of the country. Asthma prevalence in Tennessee remained stable between 2001 and 2010. In 2010, asthma prevalence was

6 percent in adults and 9.5 percent in children.[193] Asthma is more common in females than males among adults but more common in males than females among children. Adult asthma in the state is more prevalent in people with low incomes and education. Hospital charges for a primary asthma diagnosis totaled $178.8 million in Tennessee in 2010.

Figure 6.18 shows asthma prevalence rates in Tennessee, neighboring states, and nationwide. Asthma prevalence in Tennessee is lower than the national average. Tennessee also has one of the lowest asthma prevalence rates in the region. Table 6.5 shows how asthma prevalence varies across the state. The Knoxville MSA has the highest current prevalence while the Memphis MSA has the highest prevalence of lifelong asthma.

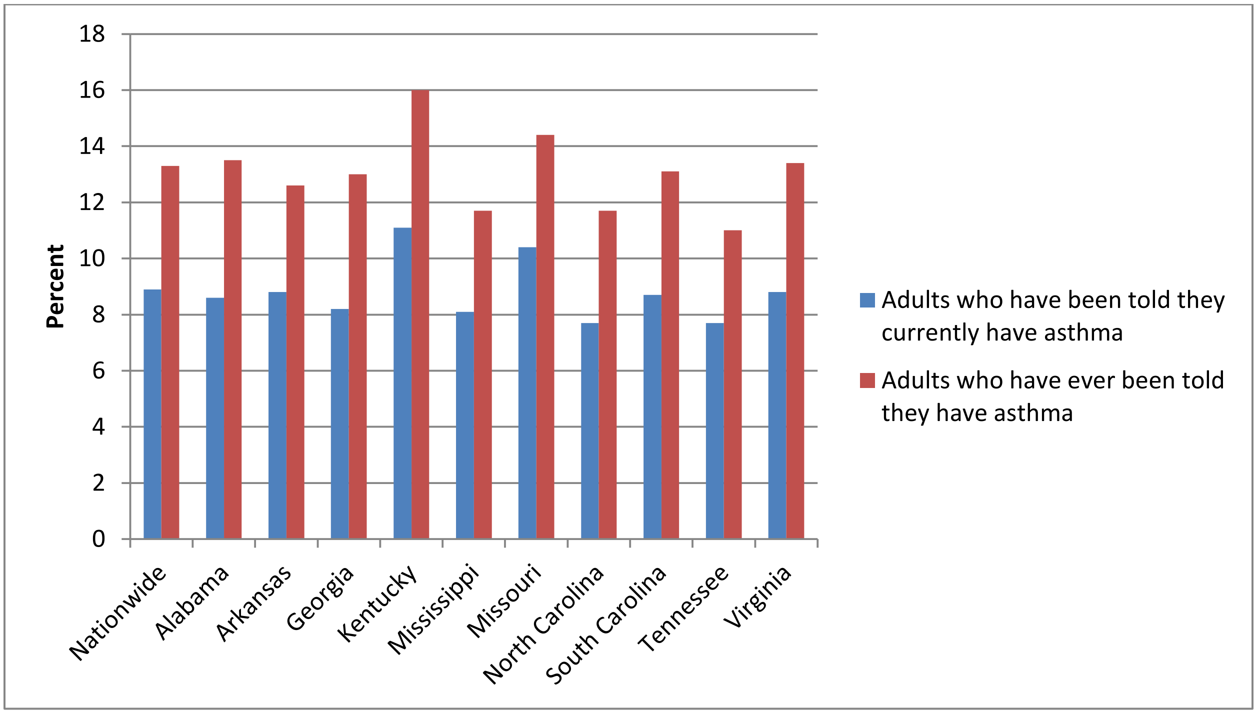

Figure 6.18. Asthma Prevalence, 2012
Source: Center for Disease Control, Behavioral Risk Factor and Surveillance System (http://apps.nccd.cdc.gov/brfss/page.asp?cat=CH&yr=2012&qkey=8411&state=TN#CH)

[193] The Burden of Asthma in Tennessee 2001-2010. Tennessee Department of Health. Released November 2012. https://health.state.tn.us/statistics/PdfFiles/BurdenofAsthma2001-2010.pdf.

Table 6.5. Asthma Prevalence Rates in Tennessee's Metropolitan Statistical Areas (MSAs), 2012

Metropolitan Statistical Area (MSA)	Counties	Percent of adults who have been told they currently have asthma	Percent of adults who have ever been told they have asthma
Chattanooga, TN-GA	Catoosa County, GA; Dade County, GA; Hamilton County, TN; Marion County, TN; Sequatchie County, TN; Walker County, GA	4.7	7.5
Kingsport-Bristol, TN-VA	Bristol City, VA; Hawkins County, TN; Scott County, VA; Sullivan County, TN; Washington County, VA	7.6	10.4
Knoxville, TN	Anderson County, TN; Blount County, TN; Campbell County, TN; Grainger County, TN; Knox County, TN; Loudon County, TN; Morgan County, TN; Roane County, TN; Union County, TN	8.4	10
Memphis, TN-MS-AR	Benton County, MS; Crittenden County, AR; DeSoto County, MS; Fayette County, TN; Marshall County, MS; Shelby County, TN; Tate County, MS; Tipton County, TN; Tunica County, MS	7.4	12.1
Nashville-Davidson--Murfreesboro, TN	Cannon County, TN; Cheatham County, TN; Davidson County, TN; Dickson County, TN; Hickman County, TN; Macon County, TN; Maury County, TN; Robertson County, TN; Rutherford County, TN; Smith County, TN; Sumner County, TN; Trousdale County, TN; Williamson County, TN; Wilson County, TN	6.7	10.4

Source: Center for Disease Control, Behavioral Risk Factor and Surveillance System (http://apps.nccd.cdc.gov/brfss/page.asp?cat=CH&yr=2012&qkey=8411&state=TN#CH)

Chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease (COPD) is a type of obstructive lung disease characterized by chronically poor airflow which worsens over time. Symptoms include shortness of breath and coughing. In contrast to asthma, lung function does not improve significantly with medication. In 2012, COPD was the fourth leading cause of death in the U.S. and the third leading cause of death in

Tennessee.[194] The most common cause of COPD is smoking but air pollution and genetics are also thought to play a smaller role. People who live in large cities with higher levels of pollution also have a higher rate of COPD compared to individuals living in rural areas. A specific link has been drawn between COPD, nitrogen oxides and sulfur dioxide which are primarily produced from vehicle emissions and burning fossil fuels at power plants. Workers in mining, automobile production, and farming have also shown an increased risk for developing COPD. However, it remains unclear whether air pollution causes COPD or exacerbates existing cases.

Figure 6.19 shows COPD prevalence rates in Tennessee, neighboring states, and nationwide. COPD prevalence in Tennessee is higher than the national average. Tennessee also has the third highest COPD prevalence rates in the region behind Kentucky and Alabama. Table 6.6 shows how COPD prevalence varies across the state. The Kingsport-Bristol MSA has the highest COPD prevalence within the state.

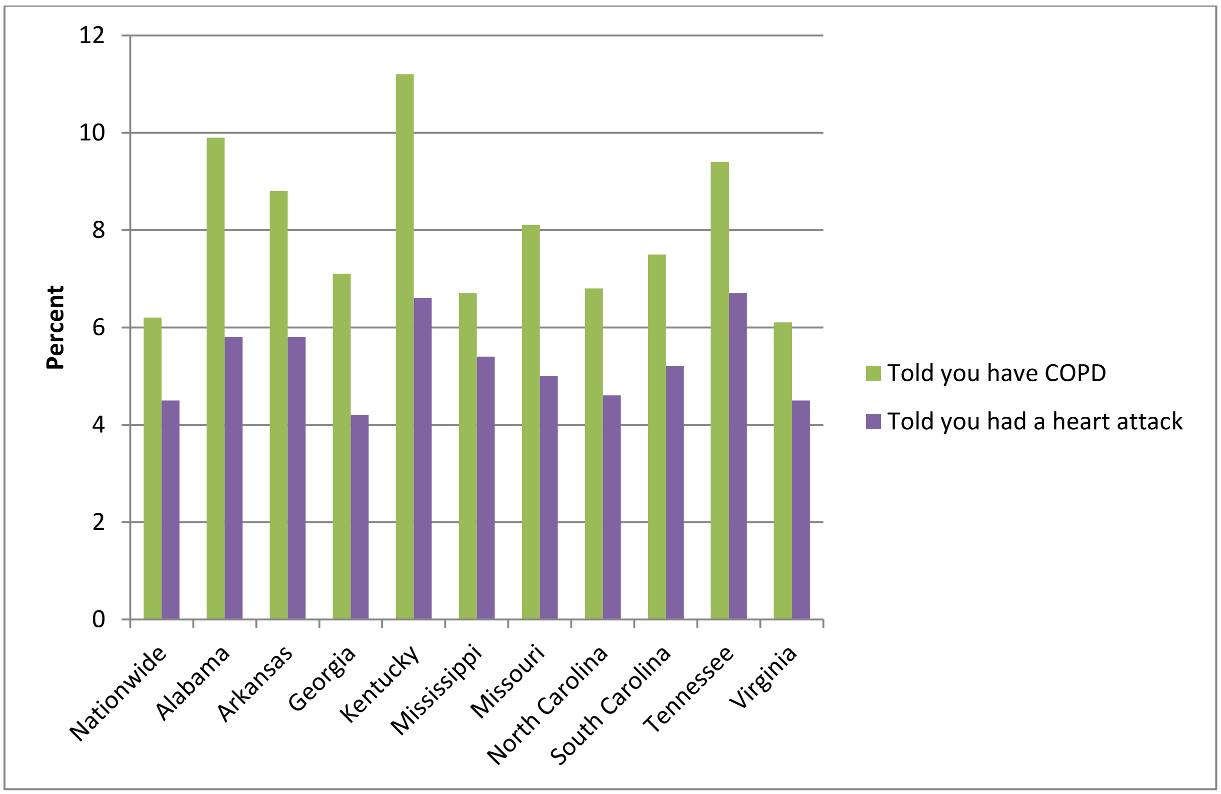

Figure 6.19. COPD and Heart Attack Prevalence, 2012
Source: Center for Disease Control, Behavioral Risk Factor and Surveillance System (http://apps.nccd.cdc.gov/brfss/page.asp?cat=CH&yr=2012&qkey=8411&state=TN#CH)

[194] Center for Disease Control and Prevention; 2012

Table 6.6 COPD and Heart Attack Prevalence Rates in Tennessee's MSAs, 2012

Metropolitan Statistical Area (MSA)	Counties	Percent told you have COPD	Percent told you had a heart attack
Chattanooga, TN-GA	Catoosa County, GA; Dade County, GA; Hamilton County, TN; Marion County, TN; Sequatchie County, TN; Walker County, GA	7.4	6.9
Kingsport-Bristol, TN-VA	Bristol City, VA; Hawkins County, TN; Scott County, VA; Sullivan County, TN; Washington County, VA	13.9	9.2
Knoxville, TN	Anderson County, TN; Blount County, TN; Campbell County, TN; Grainger County, TN; Knox County, TN; Loudon County, TN; Morgan County, TN; Roane County, TN; Union County, TN	7.5	6.5
Memphis, TN-MS-AR	Benton County, MS; Crittenden County, AR; DeSoto County, MS; Fayette County, TN; Marshall County, MS; Shelby County, TN; Tate County, MS; Tipton County, TN; Tunica County, MS	5.2	3.9
Nashville-Davidson--Murfreesboro, TN	Cannon County, TN; Cheatham County, TN; Davidson County, TN; Dickson County, TN; Hickman County, TN; Macon County, TN; Maury County, TN; Robertson County, TN; Rutherford County, TN; Smith County, TN; Sumner County, TN; Trousdale County, TN; Williamson County, TN; Wilson County, TN	7.3	5.4

Heart disease

Heart attacks have been linked to elevated levels of particulate matter which is primarily produced through the burning of fossil fuels. Heart disease is the number one killer in Tennessee and claimed the lives of 14,582 Tennesseans in 2010. Tennessee has the highest prevalence of heart disease in the region and second highest in the country behind West Virginia. The Kingsport-Bristol MSA also has the highest prevalence in the state.

Cancer

Outdoor air pollution, particularly engine exhaust and particulate matter, has recently been classified as a cancer-causing agent (carcinogen) by the World Health Organization. The International Agency for Research on Cancer (IARC), part of the World Health Organization, concluded that outdoor air pollution causes lung cancer and is also linked to increased risk for bladder cancer.

Figure 6.20 shows lung cancer incidence rates by county in the state. Incidence rates (cases per 100,000 population per year) are age-adjusted to the 2000 U.S. standard population. The highest incidence rates in the state are in the north Cumberland region, along the Tennessee River in west Tennessee, and in the southeastern portion of the state.

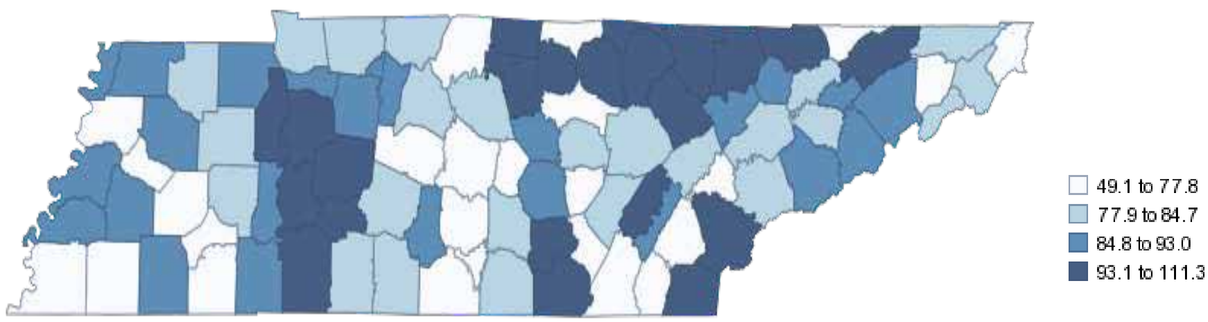

Figure 6.20. Lung Cancer Incidence Rates in Tennessee, 2012
Source: State Cancer Registry and CDC's National Program of Cancer Registries Cancer Surveillance System (NPCR-CSS)

CHAPTER 7. SUMMARY AND CONCLUSIONS

By Matthew Murray, Howard H. Baker Jr. Center for Public Policy

This report is intended to serve as a **foundational resource to support policymakers and the public as they deliberate on state energy policy and ultimately a statewide energy plan.** As such, it has covered considerable ground, from global energy markets to the nuances of instate resource extraction and energy use by final consumers and various health consequences tied to energy production and use. The purpose of this chapter is to distill some of the more distinct and salient points and provide narrative that more specifically addresses the legislative mandate to the Howard H. Baker Jr. Center for Public Policy and the Sparks Bureau of Business and Economic Research.

Global energy markets are undergoing rapid if not transformational change and this will influence the evolution of Tennessee's energy sector. The size of the energy sector, coupled with the dynamics of change, gives rise to both challenges and opportunities. There are big-picture risks, like terrorist threats to power-generating capacity and the nation's electric grid, as well as opportunities associated with potential new innovations like alternative fuels and storage batteries/facilities. Technological developments can have potentially disruptive effects on the state's energy sector. For example, a major breakthrough in vehicle storage batteries could have significant effects on the state's large and growing transportation equipment sector whose investments are now centered on the internal combustion engine. Lower natural gas prices have already had a dramatic impact on electricity power generation across the nation and within the TVA region, contributing to the decline in the use of coal by utilities. Future major breakthroughs in power generation may place additional generating capacity at risk and lead to stranded costs that would be borne by ratepayers and investors. If properly positioned, Tennessee may be able to take advantage of changes that are taking place and secure economic development gains and other benefits like environmental improvement for the state's residents and businesses.

Within this context there are at least three reasons why Tennessee's energy future will look different than its past:

The **U.S. is likely to continue reducing its dependence on foreign energy sources** and may become energy independent in the reasonably near future. While U.S. energy independence has been a campaign mantra for those seeking federal office since the early 1970's, there is evidence to suggest that the U.S. is inching closer to that goal. According to the International Energy Agency, the U.S. will be energy independent in 2035 largely due to domestic energy production. **Tennessee should pursue opportunities to exploit this increased reliance on domestic energy production.**

Coal production in the region will likely decline for the foreseeable future. Recently proposed federal limits on carbon emissions from coal-fired power plants will likely lower coal production in the region even further below current levels. It is important to recognize that coal production in the Central Appalachian Region has been declining for many years. Higher costs associated with extracting remaining reserves in the basin means higher coal prices are required to make mining economically feasible. These technical factors are the reason coal producers in the region are finding it difficult to compete with coal producers in other basins in the country. Coal producers may choose to explore opportunities to increase coal exports from the Central Appalachian Region to emerging markets such as China and India. But this strategy is already encountering difficulties as China has limited coal imports through recently announced tariffs.

Electricity generation in the state will continue to be dominated by TVA, but the **share of production coming from households and private businesses will increase** using a **new portfolio of generation technologies** in the years ahead. For the past 50 years, Tennessee's electricity generation landscape has been fairly constant. TVA served as the main generator of electricity in the state and the primary technologies used to generate this technology were coal and nuclear. Lower natural gas prices and federal carbon policies will have major implications for the generation mix regardless of generating entity. Combine these trends with improvements in distributed generation and other technologies and the state's electricity generation landscape is primed for some fairly significant changes in the years ahead.

These **changes pose challenges to the state that could be exploited as opportunities**. Here are three examples for consideration:

1. **Manufacturing**: Abundant shale oil and natural gas will put downward pressure on domestic energy prices which could continue to support the ongoing manufacturing

renaissance in the U.S. and Tennessee. This will change the manufacturing landscape in the state as new manufacturing hubs spring up in relation to domestic energy reserves and infrastructure. Tennessee must ensure energy price reductions are felt in the state to ensure that any comparative manufacturing gains the state has gained in recent years are not eroded.

2. **Rural development**: Many of Tennessee's rural communities have relied on natural resource extraction and agriculture as a source of economic development—job gains, worker paychecks and local tax revenues. The maturation of the biomass industry in the state could provide an economic boost to Tennessee's farmers and provide a more diverse mix of agricultural commodities for farmers to profit from. As traditional jobs in agriculture wane, new jobs may be created to support biomass production. The major challenge to the industry is ensuring a consistent supply of biomass feedstocks. The state could assist by helping to coordinate efforts within the state that may result in long-term supply contracts for biorefineries. (However, this strategy could harm rural economic development in these areas if farmers are unable to respond to large increases in the price of other agricultural commodities.) The decline of coal production in the region will necessitate a transition to other industries. In some cases, potential natural gas fields coincide with areas where coal production has historically been a component of economic development. But interest in Tennessee's natural gas resources will only return if the price of natural gas increases. This is likely to happen when natural gas begins to be exported in more significant volumes. The question then becomes whether prices will rise high enough to trigger exploration in the state. In many areas of the state, alternatives to the resource extraction strategy may be needed. One example would be tourism.
3. **Environment**: Air quality in the state has improved in a number of dimensions in recent years. One success story is ground-level ozone which has shown marked improvement in part because of tighter federal standards. At many times in recent years, East Tennessee, with its ridge and valley topography, has had the worst ozone levels in the country. Particulate matter (PM) is a more pressing problem today. The emergence of natural gas as a fuel source will lower emissions of a number of pollutants but its combustion can produce volatile organic chemicals (VOCs) which contribute to ground-level ozone. The transition from coal to natural gas should generally improve air quality. However, natural gas exploration and extraction in the state also poses new concerns about water quality. Recent scientific studies indicate that poorly-developed well casings and above ground storage of

wastewater are the primary causes of most of the water quality issues that have been experienced thus far. However, these studies were performed in conjunction with deep wells in Pennsylvania and Texas. Impacts on groundwater in Tennessee's more shallow shale gas plays have not been extensively studied to date. Environmental regulators in the state should be mindful to not simply trade one environmental problem from another.

In facing these challenges and opportunities, as well as others**, policy development must face three important realities.**

1. Many important energy market outcomes including **the prices we pay for our energy supplies and fuels are primarily determined by global and national markets that are not amenable to influence from state policy.** Gasoline prices, for example, are determined by supply and demand in the international market for petroleum products. Supply shocks from across the globe can affect prices here in Tennessee and there is little if anything the state can do to protect itself in the face of such external shocks. Even if the state were able to extract more oil, in-state producers would charge the prevailing market price for their product yielding little or no benefit to in-state consumers.
2. There are **numerous federal and state bodies that influence energy sector outcomes through regulations, mandates, taxes and subsidies**. For example, federal regulations place limits on nuclear technologies including the deployment of small modular reactors; the federal government determines CAFE standards which influence the fuel economy of the nation's fleet of light vehicles and thus gasoline consumption and gasoline tax revenues; rulings from the Environmental Protection Agency (EPA), including its proposed Clean Power Plan, can affect the adoption of electricity generating capacity by public utilities and the quality of the air that we breath. State policy must be developed and implemented within this complicated web where federal actions serve as a constraint on state government action.
3. Warranting **special attention is the role played by TVA as the state's primary generator and wholesaler of electric power**. TVA's unique role as an energy supplier for Tennessee and portions of six surrounding state's is reflected in its unique regulatory structure which leaves little direct role for state policy. The state can indirectly influence TVA through public posturing and by lobbying the TVA board and the state's Congressional delegation. But this influence is limited. A more fruitful approach would be for the state to

work collaboratively with TVA, the Governor's Office and the General Assembly to develop effective policies for the state. All stakeholders would need to embrace such collaboration.

The **General Assembly's request for research on a statewide energy plan included a number of specific objectives** for this study. These important areas of interest could not be addressed without the background of the report itself. Here we seek to address ***the primary objectives of interest.***

Increasing Exploration and Use of In-state or Domestic Energy Sources

This objective serves many purposes, including promoting economic development, reducing the state's reliance on global energy supplies and placing downward pressure on energy prices.

Non-Renewable Resources: The fact that many of the state's extractive resources are located in rural portions of the state means that rural residents may see economic development benefits from a strategy focused on increased resource use. **Policy development should recognize the constraints imposed by global and national energy markets and the role played by TVA** in using a portfolio of its choosing to generate power.

Chapter 5 of this report is especially important in framing opportunities for in-state resource exploration. While the state has coal reserves, they represent less than 1% of national reserves. Overall coal production is in decline and for cost reasons TVA has chosen to import out-of-state coal rather than purchase in-state coal. Given anticipated natural gas price trends, along with EPA's proposed Clean Power Plan, it is unlikely that coal extraction will play a prominent role in the future. Foreign export markets represent an opportunity for Tennessee, but rising environmental concerns abroad and shipping costs may limit this opportunity. Fracking may have potential in the Chattanooga Shale play. But the price of natural gas will have to rise before exploration can accelerate.

Renewable Resources: The state is not well endowed with particular renewable resources such as wind and geothermal. While spot applications for these energy sources exist, current technologies do not lend themselves to widespread exploitation and significant baseload power generation in the state. Biomass/woody crops and solar are more promising, but there are barriers that inhibit widespread adoption. Biomass may be of value to Tennessee's agriculture sector as it seeks diversified farming opportunities. For solar, an ongoing problem is the lack of cost-effective storage capacity for evenings and cloudy days. **Biomass, solar and fracking are all candidate areas for further consideration as means of increasing instate resource use**.

A **potential impediment to further resource use is the web of federal, state and local regulations confronted by investors**. State and local regulatory, compliance and tax burdens associated with resource discovery and extraction should be explored to ensure that they are meeting their objectives while not stifling the development of additional energy supplies. A limited but growing research effort has focused on the effect of fracking on air and water quality. This serves as a warning that providing a consistent regulatory environment while also responding to the emergence of new information on the environmental impacts of resource extraction, including fracking, will be challenging.

Promoting Job Growth, Energy Production, Energy Use and Energy Conservation in the State

If successful, fulfilling this objective would spur state economic development, increase energy supplies and place downward pressure on prices, reduce the demand for energy and yield energy cost savings for households and businesses alike.

Promoting job growth means that the energy sector must be a component of the state's overall economic development strategy. This strategy should have well-defined goals and objectives and should be amenable to evaluation for effectiveness and accountability to the public. Occupations, business and industrial sectors, investments in productive equipment, supply chains and clusters of related economic activity, and final consumers are all candidate policy targets. **Policy could focus on any part of the continuum from renewables and resource extraction to final energy use.** Specificity in policy design will enable the state to focus its business recruitment and retention strategies and any efforts to provide education and training to the workforce. The policy environment for target areas could be examined to identify impediments to private sector growth and development.

To draw this out more fully, consider renewable energy resources as an example. In this context, policy might target firms engaged in developing renewables, firm investments in equipment which can make firms more competitive, technology development to foster innovation, and worker skills to enhance worker productivity in the renewable energy sector. This approach would emphasize the role of renewable resources in Tennessee and target firms actually engaged in their exploitation. An alternative approach could focus on the cultivation of sectors that support the renewable energy industry, whether it is located in Tennessee, another state, or another country.

This might include specialized equipment and other inputs used to develop renewables, building on the state's large machinery and industrial equipment sectors. Yet another approach would seek to cultivate the siting and development of firms engaged in producing energy efficient products for final consumers. These all simply serve as broad examples of how state policy might be used to support economic development.

Energy conservation (e.g. using less energy as with a higher thermostat setting in the summer) along with **promotion of energy efficiency** (e.g. lower energy usage through more efficient air conditioners) **are important elements of a statewide energy plan.** This is especially important for households in Tennessee which consume relatively large amounts of electricity and have relatively low income by national standards (see Chapter 4). TVA and local distributors have made efforts to promote reduced energy usage. Moreover, TVA has relatively low residential electricity rates that mitigate the burden, but electricity and energy costs are still burdensome for many households. Smart or programmable thermostats, for example, would allow households to reduce energy consumption with little or no consequence for quality of life. Low-cost energy audits would allow households to identify cost-effective means of reducing energy burdens, including weatherization of the home. Loans and subsidies (e.g. sales tax credits) could be used to help households purchase energy efficient heating and cooling systems; the state's sales tax holiday could also be broadened to include weatherization and energy efficient products. Freeing up purchasing power from conservation and efficiency gains allows households to purchase other goods and services that are of value to the family, including things produced in Tennessee. Even if efficiency improvements yield no direct savings to the household budget (e.g. the higher purchase price of a new energy-efficient appliance offsets lower electricity costs), there may be other benefits to state residents, including gains for the environment, such as cleaner air.

Ensuring a Reliable, Low Cost Environmentally Responsible Energy Supply

Reliable energy supplies mitigate the likelihood and consequences of supply interruptions that disrupt the normal operations of households and businesses. Low-cost and environmentally-responsible energy supplies help ensure environmental stewardship.

Energy and fuel supply and distribution is generally handled by the market with extensive oversight from various state and federal regulatory bodies. (See the Appendix to this report for entities focused on the electricity sector.) Prices are thus a reflection of outcomes in a heavily regulated set of sectors. Electricity generation, transmission and distribution are under the purview of TVA and local retailers; motor fuel for transportation and other uses is provided through interstate pipelines and common carriers. As such, **the state's role in affecting energy sector outcomes in Tennessee is limited.**

While the state has no direct influence over TVA, as noted above, it can still use jawboning to help tilt TVA decision-making. The state also sits at the table with TVA in development of its Integrated Resource Plan (IRP) which will affect portfolio standards. TVA already has a diverse set of inputs to power generation: 45.7 percent coal, 10.5 percent natural gas, 10.2 percent hydro and 33.5 percent nuclear (see Table 4.4).

Gaining Competitive Advantages for Tennessee Businesses and Consumers in Light of Rising Costs

Maintaining a competitive business climate and attractive environment for households in Tennessee requires affordable energy costs. (For most households energy costs are a necessity and low-income households spend a disproportionate share of their incomes on energy.) However, creating and sustaining competitive advantages is exceedingly difficult given the state's natural resource base and the role played by national and international markets where market outcomes, including prices are determined. For example, fracking has made natural gas an abundant commodity in many regions of the U.S. But producers of this gas will pursue the best price possible in the marketplace which will significantly erode any localized price advantages.

A suite of strategies may nonetheless offer some protection from rising prices. As noted immediately above, **energy efficiency and conservation gains for households would reduce energy bills** so that any price shocks would in turn affect a smaller portion of the family budget.

Businesses, on the other hand, **may find protection from rising and potentially unstable energy supplies by relying on various forms of distributed generation (DG).** DG is growing in Tennessee and will likely to continue to grow as businesses self-supply more energy, thereby protecting themselves from price increases and price volatility. Any cost advantages from DG would be confined to Tennessee.

More generally it is hard if not impossible to create competitive advantages that are sustainable. Tennessee could, for example, incentivize investments in new battery technologies for light vehicles. However, if there were successful innovations that were developed in Tennessee, the benefits would spill over to national and international markets for batteries and automobiles. The state would have created an industry niche and enhanced its reputation which is of value, but many of the benefits of innovation would not stick in Tennessee. Prices would adjust to reflect market forces and production could take place elsewhere. Similarly, the in-state development of new technologies for biomass exploitation could yield job gains for workers in the biomass industry and expand state and local tax bases. But there would be little or no price advantage for Tennessee, as biofuel producers would expect to receive competitive market prices for their product.

Positioning the State as a Leader in the United States and World Energy Markets

Placing the state in a leadership role in national and global energy markets would be no small undertaking. However, s**uccessful inroads could serve as an important signal regarding Tennessee's business climate** and be an important source of economic development benefits.

Realizing any of the objectives discussed above requires a carefully-developed strategy. But putting the state in a global leadership role would necessitate an aggressive state policy stance and the active engagement of a wide array of actors including individuals, firms, industry groups, government entities and innovation assets across the state. The state's innovation assets are both numerous and varied in their scope and include the state university system, the Department of Energy's Oak Ridge National Laboratory and TVA, along with private investors, innovators and entrepreneurs.

The state would likely need to have signature public sector and private sector investments to signal its commitment to becoming a true leader in energy markets. Such investments would require considerable analysis to determine the best path for investment. The state could, as discussed above, seek to attract firms across a wide spectrum, from those making energy efficient consumer products to firms manufacturing equipment and technologies to be used in the development of renewable resources and power generation. The state's manufacturing base, with clusters and supply chains around transportation equipment, machinery, electrical equipment and appliances, and computers and electronics sectors could help serve as a springboard to growth. These sectors together accounted for about 109,400 jobs in Tennessee in 2013, or just over one-third of all manufacturing employment in the state.[195]

Demonstrating environmental stewardship in tandem with an aggressive economic development plan could help the state garner yet more attention and create more jobs. The state has unique environmental assets, including its waterways and mountains. **Successfully balancing**

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[195] *Tennessee Business and Economic Outlook*, Fall 2014. Center for Business and Economic Research, University of Tennessee, September, 2014, tables 5 and 6.

environmental stewardship against an aggressive economic development strategy could serve as a model for other states.

Incentives, Policies and Legislative and Executive Policy Recommendations to Support a Comprehensive Energy Plan for Tennessee

Several recommendations and examples have been presented in this narrative that focuses on specific objectives. Here the focus turns to **broad recommendations that should guide policy development.**

Any tax incentives, direct government outlays, mandates, regulations or other government interventions in the energy sector must be subject to some form of cost-benefit analysis to justify their use. In principle, this would include non-energy benefits such as health improvements and pollution reduction—a full assessment of benefits and costs is needed to guide policy. The state's fragile budget situation and the need to be accountable to taxpayers necessitate the use of policy that can provide good returns on the state's investment dollars. Not all good ideas represent good state policy.

The **development of a comprehensive statewide energy plan requires extensive stakeholder engagement and participation**. In other words, a statewide plan should reflect the views of a wide cross section of Tennessee households and businesses. Open meetings, focus groups and surveys could all be used to solicit input on what Tennesseans would like to see in an energy plan. A special blue ribbon committee or task force might serve as a convening and coordinating mechanism for solicitation of stakeholder input and initial policy design.

If there is a commitment to development of a comprehensive plan, consideration should be given to the establishment of a **high-level executive branch champion for energy plan coordination and development**. There is currently no overarching entity within state government to coordinate policy across agencies and serve as a single, representative voice to TVA, local and federal governments, industry, consumer groups, and so on.

Ongoing education regarding the energy sector and its evolution in Tennessee **would be of broad benefit to policymakers, the business community and the public at large.** As most readers of this report are already aware, there is very little systematic information and data regarding the state's energy sector and the many important trends that are underway. An **annual energy outlook report** may help fill this void by providing recent industry and technology trends, federal policy developments and trends on energy market outcomes in the state.

Tennessee would benefit from state-specific modeling and simulation capacity that is currently unavailable. Forecasts could be developed for the state's energy sector, framed and driven by global, national and regional trends and events. Simulation capacity and human capital expertise could be developed to evaluate alternative policies and their outcomes and effectiveness. For example, if sales tax credits were made available to Tennessee households for the purchase of energy efficient products, what would be the household adoption rate and the revenue costs to the state? How would global supply shocks affecting major energy sources such as petroleum affect the state economy? What would be the job creation impacts associated with a major thrust to develop biofuels in Tennessee?

In closing, it is hoped that this report can serve as a foundation for emerging discussions of state energy policy and a statewide energy plan. With the input of various stakeholders and sound research and modeling, Tennessee could benefit from a plan that would prove we are focused on the future and moving in a progressive way to make decisions and implement policies that will provide strategic direction for a prosperous Tennessee.

Appendix: Tennessee Energy Sector Influences – Public and Private

By Jeff Wallace, Ryan Hansen, & Lew Alvarado, Sparks Bureau of Business and Economic Research, University of Memphis

This chapter presents a compendium of major influences on Tennessee's energy sector with a specific eye on electricity generation. The primary focus is on federal and state government agencies/actors with direct roles in the market. Also included is a list of non-government entities that may exert some influence on Tennessee energy policy. While every effort has been made to include major players with a direct role, this compendium is not all inclusive. For example, it does not include governmental agencies/actors at the local level but these entities may play a role in the rates that end-customers pay. With 95 county governments and hundreds of municipal governments in Tennessee, this is beyond the scope of the current research effort.

Similarly, the list of non-government, non-industry, and mostly environmental organizations is not exhaustive but is sufficient to give the reader a flavor of non-government forces playing a role in Tennessee's energy market. While non-governmental organizations do not directly influence outcomes, they are important stakeholders that represent myriad interests from electricity consumers to environmental activists. The information provided is primarily contact related along with brief summary information from the organizations' websites**. It is important to note that claims made in the descriptions are generally those of the associated organizations and are not necessarily reflective of the views of the authors of this report.**

There is also a listing of industry organizations which is another important set of stakeholders. As industry representatives, advocacy on behalf of members is a primary activity and this may include lobbying/advocacy at the federal, state, and local levels. The listing includes groups ranging from the American Coal Council to the Tennessee Solar Energy Association. Once again, the information provided is primarily contact-related along with brief summary information from the organizations' websites.

Together this information illustrates the potential complexities associated with energy policy development and the challenges of staying abreast of policy influences on state energy market outcomes.

ELECTRONIC CODE OF FEDERAL REGULATIONS

e-CFR Data is current as of September 2, 2014

Title	*Volume*	*Chapter*	*Browse Parts*	*Regulatory Entity*
Title 10	1	I	1-50	NUCLEAR REGULATORY COMMISSION
Energy	2		51-199	
	3	II	200-499	DEPARTMENT OF ENERGY
	4		500-699	
		III	700-999	DEPARTMENT OF ENERGY
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Source: http://www.ecfr.gov/cgi-bin/text-idx?SID=ea07f8d9c1d7af18545b07ff347c45ec&tpl=/ecfrbrowse/Title10/10tab_02.tpl

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Source: http://www.ecfr.gov/cgi-bin/text-idx?SID=f94b7224609aedffe5942dd7903ed100&tpl=/ecfrbrowse/Title18/18tab_02.tpl

U.S. Department of Energy

Mission

The mission of the Energy Department is to ensure America’s security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions.

History

Regulatory

Directives

Regulatory Compliance

Policies

Energy Efficiency & Renewable Energy Regulations

TN Info

Local Office

Oak Ridge National Laboratory

In Tennessee

The US Department of Energy operates the Oak Ridge National Laboratory in Tennessee, which is the largest science and energy national laboratory in the Department of Energy system. ORNL’s scientific programs focus on materials, neutron science, energy, high-performance computing, systems biology and national security.

ORNL partners with the state of Tennessee, universities and industries to solve challenges in energy, advanced materials, manufacturing, security and physics. The laboratory's science and technology innovations are translated into applications for economic development and global security.

The laboratory is home to several of the world’s top supercomputers and is a leading neutron science and nuclear energy research facility that includes the Spallation Neutron Source and High Flux Isotope Reactor. ORNL hosts a DOE Leadership Computing Facility—home of the Titan supercomputer; one of DOE’s nanoscience centers—the Center for Nanophase Materials Sciences; the BioEnergy Science Center—one of DOE’s Energy Research Centers; and the Consortium for Advanced Simulation of Light-Water Reactors, a DOE Innovation Hub.

Environmental Protection Agency

Mission

The mission of EPA is to protect human health and the environment.

EPA's purpose is to ensure that:

● all Americans are protected from significant risks to human health and the environment where they live, learn;
● national efforts to reduce environmental risk are based on the best available scientific information;
● federal laws protecting human health and the environment are enforced fairly and effectively;
● environmental protection is an integral consideration in U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agriculture, industry, and international trade, and these factors are similarly considered in establishing environmental policy;
● all parts of society -- communities, individuals, businesses, and state, local and tribal governments -- have access to accurate information sufficient to effectively participate in managing human health and environmental risks;
● environmental protection contributes to making our communities and ecosystems diverse, sustainable and economically productive; and
● the United States plays a leadership role in working with other nations to protect the global environment.

Regulatory

Electric Utilities
Oil and Gas Extraction

Organization's Link

http://www.epa.gov/

TN Info

EPA in Tennessee
EPA Regulations in Tennessee

In Tennessee

The EPA delegates responsibilities to the TN Department of Environment and Conservation to regulate sources of air pollution, solid and hazardous waste, radiological health issues, underground storage tanks, water pollution, water supply, and ground water. The TDEC is the chief environmental and natural resource regulatory agency in Tennessee.

What federal laws does EPA enforce?

At the federal level, nine principal laws regulate the environment. These are:

- Clean Air Act (CAA)
- Clean Water Act (CWA)
- Safe Drinking Water Act (SDWA)
- Resource Conservation and Recovery Act (RCRA) (governing hazardous wastes)
- Community Right to Know Act (EPCRA) (covering a variety of reporting requirements for storage and releases of hazardous substances)
- Toxic Substances Control Act (TSCA)
- Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)(governing pesticide manufacture, sale and use)
- Superfund (CERCLA)
- Oil Pollution Act (OPA) (covering oils spills and prevention requirements)

The above laws cover four basic types of environmental regulation: end-of pipe, product regulation, public information requirements, and clean-up.

Most laws contain parts of each of these types of environmental regulations, but have one of them as their major thrust.

The Clean Air and Clean Water Act are generally end-of-pipe type laws, governing the amount of substances that can be emitted to the environment; the Safe Drinking Water Act is somewhat similar to these, but its focus is on what is allowed into public drinking water systems as well as protecting the water sources for those systems.

Product and waste regulation laws include RCRA and FIFRA.

EPCRA focuses on requirements for providing information on releases to the environment and the amounts of hazardous substances stored at a facility.

Superfund and OPA focus on responding to and cleaning up hazardous wastes sites or spills of hazardous substances.

Source:
http://compliance.supportportal.com/link/portal/23002/23009/Article/32910/What-federal-laws-does-EPA-enforce

A U.S. Power Industry Regulatory Update

09/03/2014 | Sonal Patel

From: http://www.powermag.com/a-u-s-power-industry-regulatory-update/

The U.S. power sector has seen a number of developments on the regulatory front in recent months. Here's where major federal rules stand today.

GHG Rules

New Power Plants. The Environmental Protection Agency (EPA) in September 2013 revised a 2012 proposal to limit carbon emissions from new coal- and natural gas–fired power units. The New Source Performance Standards developed under Section 111(b) of the Clean Air Act (CAA) require new gas plants of 100 MW or more to emit no more than 1,000 pounds of carbon dioxide/MWh of power produced (as achievable with the latest combined cycle technology), but calls for smaller gas plants to achieve a less-stringent standard of 1,100 pounds CO_2/MWh. Coal plants can either use carbon capture and storage technology soon after startup (to achieve a 12-month average emission rate of 1,100 lb CO_2/MWh) or after seven years of startup to achieve a seven-year average emission of between 1,000 and 1,050 lb CO_2/MWh.

Existing Power Plants. As directed by President Obama's Climate Action Plan, the EPA on June 2 proposed its "Clean Power Plan" emissions guidelines for existing power plants under the CAA Section 111(d). The proposal sets state-specific, rate-based goals and relies on four "building blocks" to establish the best approach for each state to slash power sector CO_2 emissions by 30% from 2005 levels by 2030.

BACT for GHG Emissions. The U.S. Supreme Court on June 23 reversed the EPA's Tailoring Rule but affirmed the agency's authority to regulate greenhouse gases (GHGs) under the CAA's Prevention of Significant Deterioration permit program. Specifically, the high court said the EPA could permissibly require sources that are obligated to obtain permits "anyway" (because of their emission of non-GHG pollutants) to adopt GHG Best Available Control Technology (BACT).

Mercury and Air Toxics Standards (MATS)

The U.S. Court of Appeals for the D.C. Circuit on Apr. 15 upheld MATS, rejecting numerous challenges from industry, states, and environmental petitioners. Over July and August, at least 23 states and two energy industry groups petitioned the U.S. Supreme Court to review the decision, arguing the rule would drive up power prices and harm the coal industry. The rule requires all existing coal- and oil-fired power units to meet specific, numeric emission limits for mercury, particulate matter, and acid gases by Apr. 15, 2015, unless granted a one-year extension.

Cross-State Air Pollution Rule (CSAPR)

The U.S. Supreme Court on Apr. 29 reversed and remanded the D.C. Circuit's 2012 decisionthat vacated CSAPR. The high court concluded that the EPA's approach in issuing the CSAPR as a federal implementation plan first was lawful. However, the D.C. Circuit's stay of CSAPR remains in effect, and the case now goes back to the appeals court to address substantive issues left open by the Supreme Court. More legal process is required before CSAPR is put back into effect, including certain debate over timing and compliance deadlines.

PM (2.5) Standard

The EPA in December 2012 strengthened the primary annual final particle (PM2.5) national ambient air quality standard from 15.0 micrograms per cubic meter ($\mu g/m^3$) to 12.0 $\mu g/m^3$. On Aug. 19, the agency designated 14 areas in six states as "nonattainment" and all other areas of the country as "unclassifiable/attainment." States must submit state implementation plans to meet the PM2.5 standard by fall 2016.

316(b) Cooling Water Rule

The agency on Aug. 15 published its final rule establishing requirements under Section 316(b) of the Clean Water Act for all existing power generating facilities that withdraw more than two million gallons per day of water and use at least 25% of the water they withdraw exclusively for cooling purposes—about 540 power plants. The rule goes into effect on Oct. 14, 2014.

Coal Combustion Residuals

Though proposed more than four years ago, rules governing the disposal of coal combustion residuals—including fly ash, boiler slag, and flue gas desulfurization waste products—remain in limbo. But on Oct. 29, 2013, the D.C. Circuit directed the EPA to establish a timeline for reviewing coal combustion residue regulations, and on Jan. 29, a consent decree between the agency and environmental groups was reached that requires the EPA to issue a proposed revision to its rules no later than Dec. 18, 2014.

Effluent Limitation Guidelines

A consent decree between environmental groups and the EPA reached this April suggests the final rule establishing national technology-based effluent limitation guidelines and standards to reduce wastewater discharges of pollutants from nuclear and fossil power plants will likely be delayed until September 2015. Current rules, last updated in 1983, do not "adequately" address the pollutants being discharged and have not kept pace with power sector changes, the agency says.

Ozone Standard

A California federal judge this April ordered the EPA to propose primary and secondary national ambient air quality standards for ozone by Dec. 1, 2014, and finalize them by October 2015. The rule's last revision in 2008 set the ozone standard of 75 parts per billion (ppb). But before the EPA could finalize a rule proposed in 2010 to set a stricter standard of between 60 ppb and 70 ppb, President Obama in 2011 scuttled the rule to reduce regulatory burdens and uncertainty. An August-released EPA final policy assessment provides "strong support" for revising the standard within the range of 60 ppb to 70 ppb.

Radiation Protection Standards for Nuclear Plants

The EPA on Feb. 4 proposed a thorough review of these standards, given changes in the industry and in scientific knowledge. In contrast to tightened standards for other risks, the draft version for exposure from radiological incidents proposes to substantially relax existing limits. The current standards were promulgated in 1977 to limit radiation releases and doses to the public from nuclear power plants and uranium fuel-cycle facilities.

Continued Storage of Spent Nuclear Fuel

Finalized on Aug. 26, this rule replaces the 2010 Waste Confidence Rule that was vacated by a federal court in 2012 and confirms that nuclear fuel from commercial reactors can be safely managed in reactor fuel storage pools in the short term and in steel and concrete storage containers for longer timeframes. The Nuclear Regulatory Commission (NRC) on Aug. 26 also lifted a suspension on final decisions on 19 pending reactor license applications.

Critical Infrastructure Protection (CIP) Reliability Standards

Cybersecurity Standards. The Federal Energy Regulatory Commission (FERC) on Nov. 21, 2013, approved with modifications the North American Electric Reliability Corp.'s (NERC's) Version 5 CIP reliability standards, calling for the first time for all cyber assets to be categorized as low-, medium-, or high-impact assets and approving 12 new requirements with new cybersecurity controls.

Physical Security Standards. FERC proposed to approve NERC's submitted rule to enhance physical security for the most critical bulk power system facilities on July 17. In a March 7 order, FERC determined that existing CIP reliability standards did not address physical attacks. n

—Sonal Patel is a POWER associate editor (@POWERmagazine, @sonalcpatel)

ELECTRONIC CODE OF FEDERAL REGULATIONS - ENVIRONMENTAL PROTECTION AGENCY

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Federal Energy Regulatory Commission

Acronym	**FERC**
Agency Name	**Federal Energy Regulatory Commission**
Mission	Reliable, Efficient and Sustainable Energy for Customers Assist consumers in obtaining reliable, efficient and sustainable energy services at a reasonable cost through appropriate regulatory and market means.
Primary Goals	**1.** Ensure that rates, terms and conditions are just, reasonable and not unduly discriminatory or preferential. **2.** Promote the development of safe, reliable and efficient energy infrastructure that serves the public interest.

What FERC Does
FERC is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. FERC also regulates natural gas and hydropower projects. **Economic Regulation** *Transmission and sale of natural gas for resale in interstate commerce; *Transmission of oil by pipeline in interstate commerce; *Transmission and wholesale sales of electricity in interstate commerce; *Administers accounting and financial reporting regulations and conduct of regulated companies, and; **Infrastructure Regulation** *Licenses and inspects private, municipal, and state hydropower projects; *Approves the siting of and abandonment of interstate natural gas facilities, including pipelines, storage and liquefied natural gas; and *Oversees environmental matters related to natural gas and hydropower projects and major electricity policy initiatives.

Source: www.ferc.gov/for-citizens/about-ferc.asp.

Federal Energy Regulatory Commission

Acronym **FERC**

Agency Name **Federal Energy Regulatory Commission**

Mission

Reliable, Efficient and Sustainable Energy for Customers Assist consumers in obtaining reliable, efficient and sustainable energy services at a reasonable cost through appropriate regulatory and market means.

Primary Goals

1. Ensure that rates, terms and conditions are just, reasonable and not unduly discriminatory or preferential.

2. Promote the development of safe, reliable and efficient energy infrastructure that serves the public interest.

What FERC Does NOT Do
Areas considered outside of FERC's jurisdiction are: **Economic Regulation** *Retail electricity and natural gas sales to consumers; *Oil company mergers and acquisitions; *Regulation of municipal power systems, federal power marketing agencies like the Tennessee Valley; Authority, and most rural electric cooperatives; and **Infrastructure Regulation** *Approval to construct electric generation, transmission, or distribution facilities, except hydropower; *Nuclear power plant regulation; *Oversight of oil pipeline construction; *Abandonment of service related to oil facilities; *Pipeline safety or pipeline transportation on or across the Outer Continental Shelf; *Development and operation of natural gas vehicles.

HTTP://WWW.ECFR.GOV/CGI-BIN/TEXT-IDX?SID=36E56B30FA313FA31B7A074796C50BC4&TPL=/ECFRBROWSE/TITLE18/18CFRV1_02.TPL#0

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TITLE 18—Conservation of Power and Water Resources

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For questions or comments regarding e-CFR editorial content, features, or design, email ecfr@nara.gov.
For questions concerning e-CFR programming and delivery issues, email webteam@gpo.gov.

National Energy Reliability Corporation

About

The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to ensure the reliability of the bulk power system in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the bulk power system through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the electric reliability organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the bulk power system, which serves more than 334 million people.

The ERO's key programs, which impact more than 1,900 bulk power system owners and operators, are based on four pillars of continued success:

•Reliability – to address events and identifiable risks, thereby improving the reliability of the bulk power system.
•Assurance – to provide assurance to the public, industry, and government for the reliable performance of the bulk power system.
•Learning – to promote learning and continuous improvement of operations and adapt to lessons learned for improved bulk power system reliability.
•Risk-based Approach – to focus attention, resources, and actions on issues most important to bulk power system reliability.

In Tennessee

NERC delegates authority to SERC for compliance and monitoring in Tennessee.

Legal and Regulatory

The Legal and Regulatory department provides support to several of NERC's key program areas: Compliance Operations, Investigations, and Standards. In addition, this department provides a wide range of legal support to the NERC management team regarding antitrust, corporate, commercial, insurance, contract, employment, real estate, copyright, tax, legislation, and other legal matters.

Regulatory Links

NERC Filings to FERC and FERC Orders/Rules
Canadian Filings, Orders and MOUs
Rules of Procedure
Regional Entity Delegation Agreements and Compliance Monitoring and Enforcement Agreements
Key Players
Reliability Legislation

	ERO Performance Assessment
Other NERC Resources	Other Resources
Organization's link	http://www.nerc.com/Pages/default.aspx

Southern Energy Reliability Corporation

About

The SERC Reliability Corporation (SERC) is a nonprofit corporation responsible for promoting and improving the reliability, adequacy, and critical infrastructure of the bulk power supply systems in all or portions of 16 central and southeastern states. Owners, operators, and users of the bulk power system in these states cover an area of approximately 560,000 square miles and comprise what is known as the SERC Region.

In Tennessee

SERC serves as a regional entity with delegated authority from NERC for the purpose of proposing and enforcing reliability standards within the SERC Region. SERC is divided geographically into five diverse sub-regions that are identified as Central (formerly TVA region), Delta, Gateway, Southeastern and VACAR. Tennessee is in the Central sub-region.

SERC is one of eight regional entities with delegated authority from NERC; the regional entities and all members of NERC work to safeguard the reliability of the bulk power systems throughout North America.

Compliance

The MISSION of SERC Reliability Corporation's Compliance Organization is to comprehensively monitor and enforce compliance with reliability standards among all users, owners and operators of the bulk-power system in the SERC Region. SERC's compliance monitoring and enforcement program will be conducted with integrity, consistency, confidentiality, fairness, independence and impartiality. SERC enforces standards via fines.

The VISION of SERC Reliability Corporation's Compliance Organization is to optimize reliability across the SERC Region by fostering a culture of compliance among all users, owners and operators of the bulk-power system.

Compliance Registry

Organization's Link http://www.serc1.org/Application/HomePageView.aspx

Nuclear Regulatory Commission

NRC — Independent Regulator of Nuclear Safety (NUREG/BR-0164, Revision 9)

Office of Public Affairs
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Introduction

The U.S. Nuclear Regulatory Commission (NRC), created by Congress, began operating in 1975. Its mission is to regulate commercial and institutional uses of nuclear materials, including nuclear power plants. The agency succeeded the U.S. Atomic Energy Commission, which was responsible for both developing and regulating nuclear activities. Now, federal research and development, and nuclear weapons production are done by the U.S. Department of Energy.

The NRC's overall responsibility is to protect public health and safety. Its main regulatory functions are to: establish standards and regulations; issue licenses for nuclear facilities and users of nuclear materials; and inspect facilities and users of nuclear materials to ensure compliance with the requirements.

These regulatory functions relate to both nuclear power plants and other uses of nuclear materials — such as nuclear medicine programs at hospitals, academic activities at educational institutions and research. They also relate to such industrial applications as gauges, irradiators and other devices that contain radioactive material.

Page Last Reviewed/Updated Monday, July 28, 2014

In Tenessee

NRC's Regional Office in Atlanta (Region II) is responsible for carrying out the agency's duties in Tennessee. Tennessee is an Agreement State.

Summary

*The NRC licenses all commercial nuclear fuel facilities that process and fabricate uranium into reactor fuel.

*The NRC and states also have regulatory oversight for certain radioactive materials that occur naturally or are produced by machines called particle accelerators.

*Currently operating nuclear power plants had to obtain both a construction permit, which allowed the facility to be built, and an operating license, which allowed the facility to operate.

*The NRC inspects all facilities it licenses — including more than 100 nuclear power plants in 31 states — to make sure they are meeting NRC regulations, the terms of their licenses and orders issued by the NRC.

*NRC and DOT jointly regulate shipment of radioactive materials.

*NRC's Regional Office in Atlanta (Region II) is responsible for carrying out the agency's duties in Tennessee. Tennessee is an Agreement State.

Tennessee Nuclear Power Reactors

Sequoyah Unit One Watts Bar Unit One

Unit Two

Download complete document for more information:
NUREG/BR-0164, Revision 9 (PDF - 7.76 MB)
Date Published: June 2012

Office of Surface Mining

About

The Office of Surface Mining Reclamation and Enforcement (OSMRE) is a bureau within the United States Department of the Interior. OSMRE is responsible for establishing a nationwide program to protect society and the environment from the adverse effects of surface coal mining operations, under which OSMRE is charged with balancing the nation's need for continued domestic coal production with protection of the environment.

OSMRE was created in 1977 when Congress enacted the Surface Mining Control and Reclamation Act. OSMRE works with states and tribes to ensure that citizens and the environment are protected during coal mining and that the land is restored to beneficial use when mining is finished. OSMRE and its partners are also responsible for reclaiming and restoring lands and Photo of reclaimed land, pond filled with plant life water degraded by mining operations before 1977.

OSMRE is organized with Headquarters located in Washington DC, and three regional offices – the Appalachian, Mid-Continent, and Western Regional Offices. The Regional Offices are composed of Area and Field Offices.

In its beginning, OSMRE directly enforced mining laws and arranged cleanup of abandoned mine lands. Today, most coal states have developed their own programs to do those jobs themselves, as Congress envisioned. OSMRE focuses on overseeing the state programs and developing new tools to help the states and tribes get the job done.

OSMRE also works with colleges and universities and other state and Federal agencies to further the science of reclaiming mined lands and protecting the environment, including initiatives to promote planting more trees and establishing much-needed wildlife habitat. Each year, OSMRE trains hundreds of state and tribal professionals in a broad range of needed skills.

Although a small bureau, OSMRE has achieved big results by working closely with those closest to the problem: the States, Tribes, local groups, the coal industry and communities.

Mission

Our mission is to carry out the requirements of the Surface Mining Control and Reclamation Act (SMCRA) in cooperation with States and Tribes. Our primary objectives are to ensure that coal mines are operated in a manner that protects citizens and the environment during mining and assures that the land is restored to beneficial use following mining, and to mitigate the effects of past mining by aggressively pursuing reclamation of abandoned coal mines.

Laws Laws, Regulations, and Guidance

Organization's Link http://www.osmre.gov/

TN Info [TN Offices]

In Tennessee

The Tennessee Department of Environment and Conservation operates the Land Reclamation Section with funds appropriated from the OSMRE. The Land Reclamation Section is responsible for reclaiming those mine sites that have been designated as "abandoned", meaning those sites which have been mined prior to surface mining laws, those sites with no reclamation bond, or those sites where there is no continuing obligation to the mine operator.

US Department of Transportation

Pipeline and Hazardous Materials Safety Administration

Organization's Link http://www.phmsa.dot.gov/regulations

Mission

Our mission is to protect people and the environment from the risks of hazardous materials transportation. To do this, we establish national policy, set and enforce standards, educate, and conduct research to prevent incidents. We also prepare the public and first responders to reduce consequences if an incident does occur.

Our vision is that no harm results from hazardous materials transportation. We cannot accept death as an inevitable consequence of transporting hazardous materials, so we will work continuously to find new ways to reduce risk toward zero deaths, injuries, environmental and property damage, and transportation disruptions.

Regulations

PHMSA is responsible for regulating and ensuring the safe and secure movement of hazardous materials to industry and consumers by all modes of transportation, including pipelines.

To minimize threats to life, property or the environment due to hazardous materials related incidents, PHMSA's Office of Hazardous Materials Safety develops regulations and standards for the classifying, handling and packaging of over 1 million daily shipments of hazardous materials within the United States.

The Office of Pipeline Safety (OPS) ensures safety in the design, construction, operation and maintenance, and spill response planning of America's 2.6 million miles of natural gas and hazardous liquid transportation pipelines.

In Tennessee Through certification by OPS, the state inspects and enforces the pipeline safety regulations for intrastate gas pipeline operators in Tennessee. This work is performed by Gas Pipeline Safety Division of the Tennessee Regulatory Authority. For more information, see Regulatory Fact Sheet: Tennessee at: http://primis.phmsa.dot.gov/comm/FactSheets/States/TN_State_PL_Safety_Regulatory_Fact_Sheet.htm

http://primis.phmsa.dot.gov/comm/FactSheets/States/TN_State_PL_Safety_Regulatory_Fact_Sheet.htm

US Army Corps of Engineers

Organization's Link http://www.usace.army.mil/Home.aspx

Missions

- Civil Works
- Military Missions
- Environmental
- Emergency Operations
- Research and Development
- Sustainability

In Tennessee

In Tennessee, Corps activities include dam operation and safety, electricity generation, flood risk management, and river navigation maintenance and regulation. Operations are headquartered out of Memphis and Nashville.

Nashville District

- Center Hill Dam
- Cheatham Dam
- Cordell Hull Dam
- Dale Hollow Dam
- J. Percy Priest Dam
- Old Hickory Dam

Memphis District

- Ensley Engineer Yard

Tennessee Valley Authority

About

The Tennessee Valley Authority, a corporation owned by the U.S. government, provides electricity for 9 million people in parts of seven southeastern states at prices below the national average. TVA, which receives no taxpayer money and makes no profits, also provides flood control, navigation and land management for the Tennessee River system and assists utilities and state and local governments with economic development. Website: http://www.tva.com/

more about TVA...

Mission

TVA has renewed its vision to help lead the Tennessee Valley region and the nation toward a cleaner and more secure energy future, relying more on nuclear power and energy efficiency and relying less on coal.

History

The Tennessee Valley Authority is the nation's largest public power provider and a corporation of the U.S. government. TVA was established by Congress in 1933 to address a wide range of environmental, economic, and technological issues, including the delivery of low-cost electricity and the management of natural resources. TVA's power service territory includes most of Tennessee and parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina and Virginia, covering 80,000 square miles and serving more than 9 million people. TVA sells electricity to 155 power distributor customers and 56 directly served industries and federal facilities.

more on TVA history...

Other Topics

Corporate Reports
2012 Preformance
Economic Development
Green Power Providers
Power Prices
Renewable Energy
Renewable Standard Offer
Supplier Management
Tax Equivalent Payments
Wholesale Rate Change

Power

Fossil-Fuel Generation
Hydroelectric Power
Nuclear Energy
Transmission
Customers

FAQ

TVA FAQ

TVA in Tennessee, Fiscal Year 2013 (October 2012 – September 2013)

http://www.tva.com/news/state/tennessee.htm .

Energy Sales

•In fiscal year 2013, TVA sold more than 91 billion kilowatt-hours of electricity to 61 municipal and 22 cooperatively owned utilities that distribute power in Tennessee.

•The local power companies provided over 39 billion kilowatt-hours of electricity to more than 2.6 million Tennessee households in 2013.

•Local power companies' sales to almost 448,000 commercial and industrial customers totaled 47.3 billion kilowatt-hours. In addition, these local power companies in Tennessee sold more than 1 billion kilowatt-hours to outdoor lighting customers.

•Tennessee is home to 23 directly served customers of TVA that purchased over 5.9 billion kilowatt-hours of electricity.

•TVA power revenues in Tennessee in fiscal year 2013 totaled more than $6.8 billion, or about 62 percent of all TVA operating revenue.

Service Area

•TVA serves virtually all of the 95 counties in Tennessee.

•The TVA service area in Tennessee covers about 42,038 square miles, about 49 percent of TVA's territory and 99.7 percent of Tennessee. This includes an electricity service area of 41,420 square miles and a watershed management area of 22,514 square miles.

Power Generation and Transmission

In Tennessee, TVA operates 19 hydroelectric dams, six coal-fired power plants, two nuclear power plants, seven combustion turbine sites and a pumped-storage plant, with a combined generating capacity of more than 19,655 megawatts.

•Coal-fired plants: Allen, Bull Run, Cumberland, Gallatin, Johnsonville and Kingston.

•Natural gas-fueled combustion turbines: Allen, Brownsville, Gallatin, Gleason, John Sevier, Johnsonville and Lagoon Creek.

•Nuclear plants: Sequoyah and Watts Bar.

•Hydroelectric plants: Boone, Cherokee, Chickamauga, Douglas, Fort Loudoun, Fort Patrick Henry, Great Falls, Melton Hill, Nickajack, Norris, Ocoee 1, Ocoee 2, Ocoee 3, Pickwick Landing, South Holston, Tims Ford, Watauga, Watts Bar and Wilbur.

•Pumped-storage hydroelectric plant: Raccoon Mountain.

•TVA owns or maintains 263 substations and switchyards and 9,444 miles of transmission line in Tennessee.

•TVA operates ten solar facilities in Tennessee: a 35-kilowatt facility at the Adventure Science Center in Nashville; two 10-kilowatt facilities at Dollywood in Pigeon Forge; a 17-kilowatt facility at Ijams Nature Center in Knoxville; a 10-kilowatt facility at Cocke County High School in Newport; a 17-kilowatt facility at the American Museum of Science and Energy in Oak Ridge; an 8 kilowatt facility at Morgan County Vocational School in Wartburg; a 97-kilowatt facility at Finley Stadium in Chattanooga, a 19-kilowatt facility at Gibson County High School in Dyer, and a 32-kilowatt facility at the Bridges Center in Memphis.

•TVA coordinates operations at four projects in western North Carolina and east Tennessee owned by Brookfield Renewable Energy.

•Methane gas – a source of renewable energy – from the city of Memphis' wastewater treatment plant is burned with coal at TVA's Allen Fossil Plant, adding 8 megawatts of generating capacity.

•TVA is completing construction of Watts Bar Nuclear Plant Unit 2, in Spring City. This second reactor will add more than 1,100 megawatts of nuclear generating capacity when it comes online. It will be the nation's first new nuclear generation of the 21st Century.

Land and Water Stewardship

•TVA manages 33 reservoirs in Tennessee: Boone, Cherokee, Chickamauga, Douglas, Fort Loudoun, Fort Patrick Henry, Great Falls, Melton Hill, Nickajack, Nolichucky, Normandy, Norris, Ocoee 1, Ocoee 2, Ocoee 3, Raccoon Mountain, South Holston, Tellico, Tims Ford, Watauga, Watts Bar and Wilbur along with eight small reservoirs in the Beech River watershed in West Tennessee and portions of Kentucky, Pickwick and Guntersville reservoirs. The reservoirs have a combined surface area of about 300,000 acres and about 7,000 miles of shoreline.

•TVA manages recreational, natural and cultural resources on more than 170,000 acres of public land around these reservoirs and partners with state, local and regional stakeholders to improve water quality, shoreline conditions, recreation and biodiversity.

•The TVA visitor center at Raccoon Mountain Pumped-Storage Plant welcomes more than 10,000 visitors every year and is TVA's largest hydroelectric facility. The Norris Dam Visitor Center overlooking the powerhouse, Norris Reservoir and a marina received almost 6,000 visitors in 2013.

•Tennessee residents enjoy camping, fishing, boating, swimming and other recreational opportunities provided by the reservoirs, as well as economic benefits of recreation and tourism. TVA's seven campgrounds in Tennessee recorded 51,888 overnight stays in 2013. TVA also maintains 41 day-use recreation areas and 45 stream access sites.

River Management

•TVA maintains the structural, seismic and hydraulic integrity of 19 hydroelectric dams, 11 non-power dams, two small overflow detention dams at John Sevier Fossil Plant on the Holston River and Doakes Creek on Norris Reservoir, and one pumped-storage plant near Chattanooga.

•TVA manages flows to support thermal compliance at our coal-fired and nuclear plants.

•TVA owns seven locks in Tennessee (six main locks and one auxiliary lock), serving about 110 Tennessee ports and terminals. About 17.2 million tons of cargo move through the facilities annually.

•TVA operates the dams and reservoirs in Tennessee as part of an integrated multi-purpose reservoir system to provide numerous stakeholders a variety of benefits which can include: navigation, flood risk reduction, low-cost hydropower, water supply, water quality, and recreational opportunities. At Chattanooga, which is prone to flooding because of its location just above where the Tennessee River flows through the narrow passes of the Cumberland Mountains, operation of TVA's flood-control system has helped prevent about $4.9 billion in flood damage since its construction.

•About 93 municipalities, 32 industries and seven mining companies in Tennessee draw water from the Tennessee River system. Water also is drawn for power plant cooling and irrigation.

•TVA schedules releases of water from the Apalachia, Norris, Ocoee 1, Ocoee 2, Ocoee 3, Tims Ford and Watauga/Wilbur dams to support tailwater recreation in Tennessee.

Other TVA Operations

•TVA's recently built Lagoon Creek Combined Cycle Plant, which occupies 181 acres in the midst of Tennessee farm country, is expected to help TVA meet the rapidly growing summertime peak demands for power with its generating capacity of 550 megawatts.

•TVA, local, state and federal agencies continue to work on recovery and clean-up of a release of ash at TVA's Kingston Fossil Plant in East Tennessee.

•Tennessee households had 26.6 million kilowatt-hours of energy efficiency savings resulting from 15,000 In-Home Energy Evaluations by TVA-certified evaluators and approximately 8,300 do-it-yourself home energy evaluations taken online or by paper survey.

Personnel

•There are 8,447 TVA employees who live in Tennessee.

•Tennessee is home to over 14,100 TVA retirees and their families.

Tax Equivalent Payments

•TVA paid $337.6 million in lieu of taxes to Tennessee in 2013, based on power sales and power property values in the state.

Economic Development

•TVA works with local power companies, directly served customers, and regional, state and community organizations to create economic development opportunities for the TVA region. Economic development focuses on attracting and retaining jobs, capital investment, and helping communities prepare for growth. During fiscal year 2013, over 32,550 jobs were created or retained in Tennessee and more than $2.9 billion was invested.

TVA Suppliers

•In fiscal year 2013, TVA purchased $267 million in nonfuel materials and services from Tennessee vendors.

Tennessee Regulatory Authority

Utility Division

The Utilities Division assists the Authority in establishing and implementing policy regarding Tennessee's gas, water, sewer, waste water, electric, and telephone companies to result in fair and responsible regulation for all utility companies and consumers in the state.

Economic Analysis and Policy Division

The Economic Analysis and Policy Division is responsible for investigating and formulating recommendations on cost, pricing, rate design, allegations of anticompetitive practices and other economic issues. The Division is responsible for identifying and analyzing market trends including monitoring and evaluation of the impact of TRA decisions on market outcomes in the industries under the agency's purview. The division has primary responsibility for reviewing applications for approval of mergers, acquisitions, and the issuance of new financial instruments by public utilities. The Economic Analysis and Policy Division also provides auxiliary functions to other divisions by providing analysis and correspondence on economic matters in numerous proceedings coming before the Authority.

Certificate of Public Convenience and Need (CCN)

http://www.tn.gov/tra/energyfiles/CCN_Guidelines.pdf

Proposed electric distributors/producers cannot operate without TRA approval. Must prove incumbent businesses in area unable or unwilling to serve proposed market.

Source: http://www.tn.gov/tra/econ.shtml

Tennessee Attorney General, Consumer Advocate

Established in 1994 by the General Assembly, the Consumer Advocate represents the interests of Tennessee consumers of investor-owned electric, natural gas, telephone, water, and sewer companies. Generally, the Consumer Advocate seeks to enforce laws applicable to public utilities, to remove barriers to competition in public utilities markets, and to seek a healthy balance between regulation, competition and the public interest.

The Consumer Advocate participates in regulatory proceedings and monitors complaints filed against various utilities in the state. The majority of the formal advocacy involves proceedings before the Tennessee Regulatory Authority (TRA.) The TRA is the agency responsible for regulating Tennessee's investor-owned utility companies. The Consumer Advocate reviews rate filings, applications, and other matters, participates in proceedings, offers expert testimony, and files legal motions and briefs as necessary.

Source: http://www.tn.gov/attorneygeneral/utility/utility.html

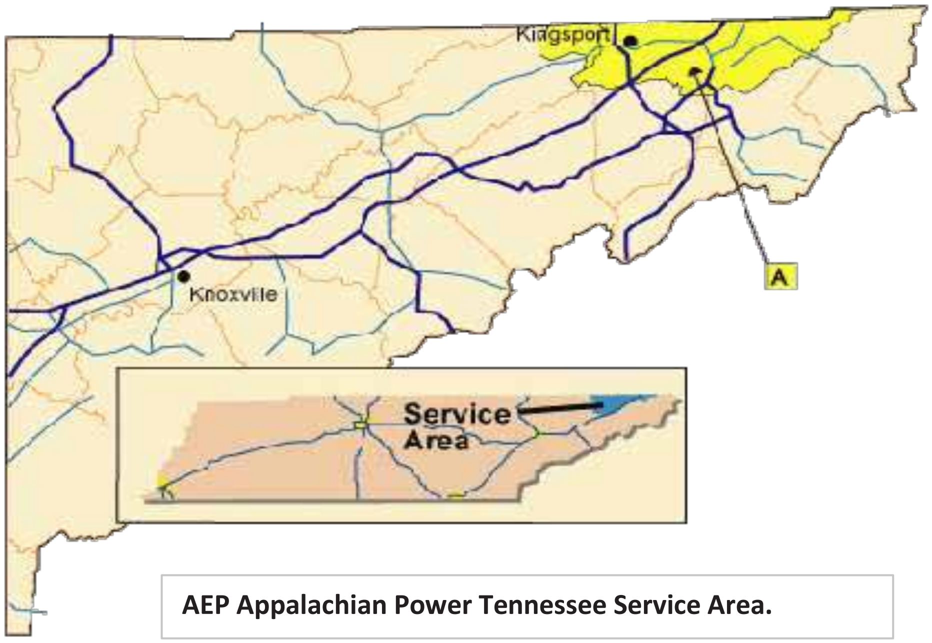
Tennessee Department of Environment and Conservation

About

The Office of Energy Programs transferred to TDEC from the TN Department of Economic and Community Development on January 1, 2013, following Governor Haslam's Executive Order No. 25. The Office of Energy Program's grant administration and energy-related education and outreach fit well with TDEC's mission and priorities. Their grant, education and outreach activities complement TDEC's work in energy efficiency, energy conservation and support for renewable fuels as it reduces overall demand for energy and fossil generated power specifically. We are pleased to have the new Office of Energy Programs at TDEC

Organization's Link http://www.tennessee.gov/environment/energy.shtml

AEP Appalachian Power serves the Kingsport, Tennessee, area and is the largest non-TVA producer of electricity in Tennessee. AEP Appalachian Power rates and tariffs are governed by the Tennessee Regulatory Authority (TRA). Specifically, AEP Appalachian Power serves Kingsport, Mount Carmel, and parts of Sullivan, Washington and Hawkins Counties.



AEP Appalachian Power Tennessee Service Area.

Source: https://www.appalachianpower.com/info/news/rates/tennessee/

Other Non-TVA Providers

•Entergy Arkansas serves approximately 60 customers in Tennessee in the parts of Shelby, Tipton, and Lauderdale Counties that extend over the west bank of the Mississippi River.

•Kentucky Utilities Company (KU) is a subsidiary of Louisville Gas and Electric Corporation, a vertically integrated electricity supplier. KU provides service to approximately 5 customers in Claiborne County, Tennessee.
Source: http://www.state.tn.us/tra/reports/electric.pdf

Non-Industry Organizations

Organization/Phone number	Webpage	Description
Consumer Alliance For Energy Security (713) 337-8800	www.consumerenergyalliance.org	Consumer Energy Alliance is the voice of the energy consumer. We provide consumers with sound, unbiased information on U.S. and global energy issues. Our affiliates comprise a range of sectors from the energy industry, academia, small businesses, conservation groups to travel-related industries.
The Nature Conservancy (615) 383-9909	www.nature.org	This national organization works with business and property owners in a non-confrontational manner to protect ecologically important lands and waters for nature and people. Extensive work in Tennessee with local headquarters in Nashville.
The Sierra Club, Tennessee Chapter (615) 837-3773	http://tennessee.sierraclub.org/index.aspx	Established in 1892, the club is the largest grassroots group in the U.S. seeking energy solutions to combat global warming. It publishes a newsletter and has affiliates in the four major cities in Tennessee.
Southern Alliance For Clean Energy Action Fund (865) 637-6055	www.cleanenergyactionfund.org	Non-partisan, non-profit political arm of the Southern Alliance for Clean Energy promoting education, legislative action and electoral accountability.
Southern Environmental Law Center (615) 921-9470	www.southernenvironment.org	With an office in Nashville, the SELC works with some 150 groups in AL, GA, SC,NC, VA and TN to use the power of of the law to protect the environment.
Tennessee Citizens For Wilderness Planning (865) 481-0286	www.tcwp.org	Established in 1966, this is a grassroots group primarily interested in the protection of the Cumberland and Appalachian areas in Tennessee.

Tennessee Clean Water Network (865) 552-7007	www.tcwn.org	Established in 1998, the TCWN engages in public participation to advocate for strong policies and programs to protect state water resources and prevent pollution.
Tennessee Conservation Voters (615) 269-9090	www.tnconservationvoters.org	Tennessee Conservation Voters is a coalition of state conservation groups dedicated to raising voter awareness, advocating stronger laws and holding our elected leaders accountable for safeguarding the environment of Tennessee.
Tennessee Environmental Council (615) 248-6500	www.tectn.org	Established in 1970, the TEC is a statewide group with some 250 members and publishes the Tennessee Green Book directory.
Tennessee Wildlife Resources Foundation (615) 831-9311	www.twrf.net	Established in 1999, the TWRF is a non-profit group of 18 corporate partners working closely with the TWRA for habitat conservation. It also publishes a newsletter.
Wild South (828) 258-2667	www.wildsouth.org	Grassroots group promoting advocacy for protecting the wild legacy with special interest in 20,000 acres in Tennessee.
The Wildlife Society (301)-897-9770	www.wildlife.org/tennessee	Established in 1937, The Wildlife Society has some 10,000 members and generates eight publications related to scientific and educational interest. Provides certification and professional development. The Tennessee chapter was established in 1968.
Wilderness Society (800) 843-9453	www.wilderness.org	Since 1935, The Wilderness Society has led the effort to permanently protect nearly 110 million acres of wilderness in 44 states. Primary focus in Tennessee is on the Appalachian mountains and the Great Smoky Mountains National Park.

Industry Organizations

Organization/Phone number	Webpage	Description
American Coal Council (202) 756-4540	www.americancoalcouncil.org	American Coal Council (ACC) provides relevant educational programs, market intelligence, advocacy support and peer-to-peer networking forums to advance members' commercial and professional development interests. ACC represents the collective interests of the American coal industry ~ from the hole-in-the-ground to the plug-in-the-wall ~ in advocating for coal as an economic, abundant and environmentally sound fuel source.
American Coalition For Ethanol (605) 334-3381	www.ethanol.org	The American Coalition for Ethanol is a lobbying association for the ethanol industry.
American Gas Association (202) 824-7000	www.aga.org	The American Gas Association represents more than 200 local energy companies that deliver clean natural gas throughout the United States. There are more than 71 million residential, commercial and industrial natural gas customers in the U.S., of which 94 percent — more than 68 million customers — receive their gas from AGA members.
American Petroleum Institute (202) 682-8000	www.api.org	The American Petroleum Institute (API) is the only national trade association that represents all aspects of America's oil and natural gas industry, with more than 600 members representing "producers, refiners, suppliers, pipeline operators, and marine transporters".
American Wind Energy Association (202) 383-2500	www.awea.org	The American Wind Energy Association (AWEA) is the national trade association for the U.S. wind industry. AWEA association ranks Tennessee 36th in megawatts installed.
Edison Electric Institute	www.eei.org	The Edison Electric Institute (EEI) is the association that represents all U.S. investor-owned electric companies. Our members provide electricity for 220 million Americans, operate in all 50 states and the District of Columbia, and directly employ more than 500,000 workers. EEI has 70 international electric companies as Affiliate Members, and 270 industry suppliers and related organizations as Associate Members.

Energy Technology and Environmental Business Alliance (877) 693-8322	www.eteba.org	Originally formed in Oak Ridge in 1989, the Energy Technology and Environmental Business Association (ETEBA) is a non-profit trade association representing more than 250 small, large and mid-sized companies that provide environmental, technology, energy, engineering, construction and related services to government and commercial clients.
National Hydropower Association (202) 682-1700	www.hydro.org	The National Hydropower Association (NHA) is a nonprofit national association dedicated exclusively to promoting the growth of clean, affordable hydropower, America's leading renewable resource.
National Rural Electric Cooperative Association (703) 907-5500	www.nreca.coop	NRECA is the national service organization for more than 900 not-for-profit rural electric cooperatives and public power districts providing retail electric service to more than 42 million consumers in 47 states and whose retail sales account for approximately 12 percent of total electricity sales in the United States.
Nuclear Energy Institute (202) 739-8000	http://www.nei.org/	The NEI, with member participation, develops policy on key legislative and regulatory issues affecting the industry. NEI then serves as a unified industry voice before the U.S. Congress, executive branch agencies and federal regulators, as well as international organizations and venues. NEI also provides a forum to resolve technical and business issues for the industry.
Renewable Fuels Association (202) 289-3835	www.ethanolrfa.org	The RFA has been the industry's most forceful advocate for expanding the market for ethanol. Just as important, we've worked to beat back aggressive challenges to ethanol's progress from special interests seeking to maintain fossil fuel status quo.
Solar Energy Industries Association (202 682-0556	www.seia.org	As the national trade association in the U.S., the Solar Energy Industries Association (SEIA) is the power behind solar energy. Our member companies research, manufacture, distribute, finance, and build solar projects domestically and abroad.

Tennessee Electric Cooperative Association (615) 367-2495	www.tnelectric.org	Chartered in 1942, the TECA serves its member electric cooperative systems and their member-owners, including 23 individual power distributors, and one municipal system.
Tennessee Environmental Council (615) 248-6500	www.tectn.org	Established in 1970, the TEC is a statewide group with some 250 members and publishes the Tennessee Green Book directory.
Tennessee Natural Gas Association (615) 872-2413	www.tngas.org	Trade association to "promote, educate, advocate and collaborate" and to enhance the performance and safety of the natural gas industry in Tennessee.
Tennessee Oil and Gas Association (615) 371-6137	http://www.tennoil.com/	Established in 1971, this is an organization of independent oil and gas producers involved in the exploration, development, and production of oil and gas in Tennessee.
Tennessee Solar Energy Association (865) 974-9218	www.tnsolarenergy.org	Dedicated to educating Tennesseans about the many unique benefits of using solar energy. We believe that widespread adoption of solar technology in the state of Tennessee will help create energy independence, lessen harmful environmental impacts, and result in cost savings for consumers.
Tennessee Solar Energy Industries Association (865) 813-2110	www.tenneseiasolar.com	TenneSEIA (Tennessee Solar Energy Industries Association) is the state chapter for the national Solar Energy Industries Association, and represents the interest of the solar energy industry in Tennessee. The mission of TenneSEIA is to make solar energy a mainstream energy source and realize the full potential of the solar industry in Tennessee.