FRANKLIN COUNTY ENERGY STUDY

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EXECUTIVE SUMMARY

Energy is a common thread woven throughout every aspect of our lives. It is a link between all sectors of the economy, our health, and the environment. Energy connects us to our past and will be our legacy for generations to come. As we strive to meet our current challenges and transform them into future opportunities, it is essential to have a thorough understanding of how we produce our energy, the way it is utilized, and the impact it is having on our communities.

This study should serve as a baseline for Franklin County's energy production, usage, and impacts. By analyzing how energy flows from its source to where we live and work, how we use it, and how this process changes our environment, we can begin to develop ways to increase the beneficial effects it has on our economy as well as mitigate the consequences to our land, air, and water. The Franklin County Energy Study can serve as a starting point from which success is measured.

Franklin County is a net importer of energy. Nearly 100 percent of the electricity, heating, and transportation fuels consumed within the county are imported from outside the county. In 2015, the county spent $4.4 billion on end-use energy, or nearly eight percent of the county's total personal income of $58.8 billion for 2015.[1,2] This amount represented a significant economic outflow from the local economy.

Primary energy (i.e. coal, nuclear, natural gas, hydro, wind, etc.) converted to electricity for use in the county's residential, commercial, industrial, and transportation sectors represented the county's largest consumption of energy. Petroleum, consumed largely by the transportation sector, represented the second largest portion of the county's primary energy consumption. Within the transportation sector, gasoline represented half of the petroleum usage, with the majority of the remainder split fairly evenly between diesel and aviation fuels.

The use of renewable energy accounts for little of the end-use energy for the residential and commercial sectors; it accounts for only four percent of industrial energy and four percent of energy for transportation. Overall, renewable energy accounts for three percent of all end-use energy in Franklin County. Photovoltaic (PV) capacity has increased at an average annual growth rate of 65 percent since 2010.

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[1] Personal income is the income received by, or on behalf of, all persons from all sources: from laborers in production, owning a home, unincorporated business, or financial assets, and from government, and business in the form of transfer receipts. It includes income from domestic sources as well as from the rest of the world. It does not include realized or unrealized capital gains or losses.

[2] All dollar amounts reported in constant 2015 US dollars unless otherwise noted.

In 2015, residents and businesses consumed a total of 380 trillion British thermal units (TBtu) of primary energy. Of that amount, 260 TBtu or 69 percent is estimated to be unused. While that figure may be surprising, it is not unique to Franklin County. At the national level, the United States' percentage of unused energy was only slightly lower at 68 in 2015.[3] The largest portion of this unused energy results from electric system losses (heat loss) from thermo-electric generation facilities, the majority of which are located outside Franklin County and out of the direct control of the county's energy consumers. Opportunities do exist within the county to improve energy efficiency directly in the "end-use" residential, commercial, industrial and transportation sectors. In the residential sector alone, 19 TBtu of energy is unused and would be enough to support the site energy needs of 168,000 Franklin County households. These losses represent approximately $3 billion in energy expenditures, some of which can be recovered by on-site generation and improving efficiencies within our homes and transportation systems.

This energy baseline study also examined energy consumption at the ZIP Code level. This level of micro-analysis holds the potential to help Franklin County identify opportunities for energy efficiency improvements. There is wide variation in development patterns and energy use at the ZIP Code level, which makes it necessary to conduct additional research into what may be driving the patterns of consumption at this level of geographic detail.

Over the six years studied, total energy consumption in Franklin County remained fairly unchanged, despite a relatively rapid rise in population and economic growth. As a result, energy use per capita has dropped below state and national averages. Likewise, energy productivity for the county (the dollars of personal income per unit of energy consumed) rose above state and national averages, suggesting an improvement in Franklin County competitiveness and community resilience.

Multiple options are available in Franklin County to improve the energy efficiency of homes, businesses and transportation. Support for these initiatives can be found in utility programs through incentives and education, as well as financing mechanisms at the local level through the county's EnergyWorks and Property Assessed Clean Energy (PACE) programs.

With an exceptional amount of growth and support in Franklin County, ample potential exists to capitalize on an improved and more modernized energy system. The Franklin County Energy Study illuminates areas of opportunity for future security and prosperity, and provides a foundational step toward developing and implementing a strategic and proactive regional energy plan. These recommendations include investing in local and on-site generation, approaching the

[3] The Department of Energy's Lawrence Livermore National Laboratory annually produces a graphical depiction US energy consumption https://flowcharts.llnl.gov/content/assets/images/charts/Energy/Energy_2015_United-States.png

energy burden of low-income residents through area specific programs, and engaging residents and businesses in an active dialogue regarding maximizing future returns on their energy choices.

At the request of the Advisory Committee, further analysis was conducted in order to develop a set of recommendations for Franklin County. Although the recommendations document is separate in order to maintain the objectivity of the baseline, it is expected to be released concurrently with the Franklin County Energy Study.

Franklin County In 2015

380 TBtu of energy used across all sectors

4.4 billion dollars spent on energy

21 million metric tons of CO_2e created

$4 Billion in Opportunity

- Increase on-site generation and community energy projects
- Improve the energy efficiency of homes and businesses
- Electrify the transportation system and increase support for alternative fuels
- Develop educational and efficiency programs to target communities with the highest energy burdens

65% Average annual growth rate of PV capacity since 2010 in Franklin County

How to Use This Report

The Franklin County Energy Study provides a data-driven assessment of energy use and production across key sectors of the economy in order to:

1. Establish a quantified foundation for understanding energy production, use, and outcomes;
2. Provide a shared basis for identifying region-specific energy issues, opportunities, and needs;
3. Provide county and localized data to catalyze stakeholder engagement and identify priorities for action; and
4. Establish an initial baseline for tracking progress.

The profile examines how much and how intensively energy is produced, imported, consumed, and lost annually by Franklin County, Ohio. As such, this analysis serves as a quantitative baseline for guiding future regional energy policies and strategies, setting actionable energy goals, and benchmarking progress towards those established goals and strategies.

Establishing the Energy Baseline for Franklin County

This report comprehensively inventories all major forms of energy produced and consumed within Franklin County. We leveraged energy utility data along with public energy production and consumption data largely made available by the U.S. Department of Energy's Energy Information Administration (EIA). The complete methodology and data sources are included in the appendices.

Production data were publicly available at the county level. Electricity and natural gas consumption at the county level were generously supplied by the utilities serving the region. All other regional energy consumption was estimated from publicly available, state-level energy use intensities across residential, commercial, industrial and transportation sectors. These data were then downscaled to ZIP Code scale resolution. This approach allowed us to examine energy use on a relatively local scale for the entirety of Franklin County.

ENERGY PARTNERS

Using data from the energy assessment to develop recommendations and drive policy change requires participation and expertise from multiple sectors – public, private and nonprofit:

- **Utilities** – both public and private – serve residents, commercial businesses and industry;
- **State** and **federal government** regulations and actions drive macro-level changes to the efficiency and emissions of everything from vehicles, housing, and appliances, to production, generation, and refinement facilities;
- **Local nonprofits** can advocate for and implement initiatives to address energy efficiency needs, mitigate environmental impacts, and leverage opportunities for economic impact;
- **Local government** policies impact energy consumption in a myriad of "unseen" ways, by organizing our land uses and affecting transportation options – both of which substantially affect our energy usage; and
- **Members of the public** make individual choices about energy that not only affect their own budgets, but also have community-wide impacts.

Each of these players bring different interests, needs, and priorities to the table. All have an important role to play and actions to take in increasing energy efficiency and renewable energy use. During the Study, these stakeholders participated in an Advisory Committee that guided the process. Additional stakeholder input was gathered during a public comment period, at which time a draft version of the Study was available online and presented as a webinar. Input was solicited via written comments, email, phone and webinar.

The following organizations and communities assisted in the development of this study: AEP Ohio, American Municipal Power, Buckeye Power, City of Columbus, Clean Fuels Ohio, Columbia Gas of Ohio, Columbus-Franklin County Finance Authority, Columbus Regional Airport Authority, COTA, Franklin County, Go Sustainable Energy, LLC, Homeport, Madison Township, New Morning Energy LLC, Ohio Advanced Energy Economy, Ohio Air Quality Development Authority, Ohio Development Services Agency, Ohio Environmental Council, Ohio Farm Bureau Federation, Ohio Hospital Association, Ohio Partners for Affordable Energy, South Central Power, The Ohio State University, and the Village of Lockbourne.

ENERGY DEFINED

Simply defined, energy is the ability to do work

Energy comes from many sources, including heat, light, motion, electricity, gravity, chemical reactions, and nuclear reactions. How we interact with energy, however, is not as straightforward.

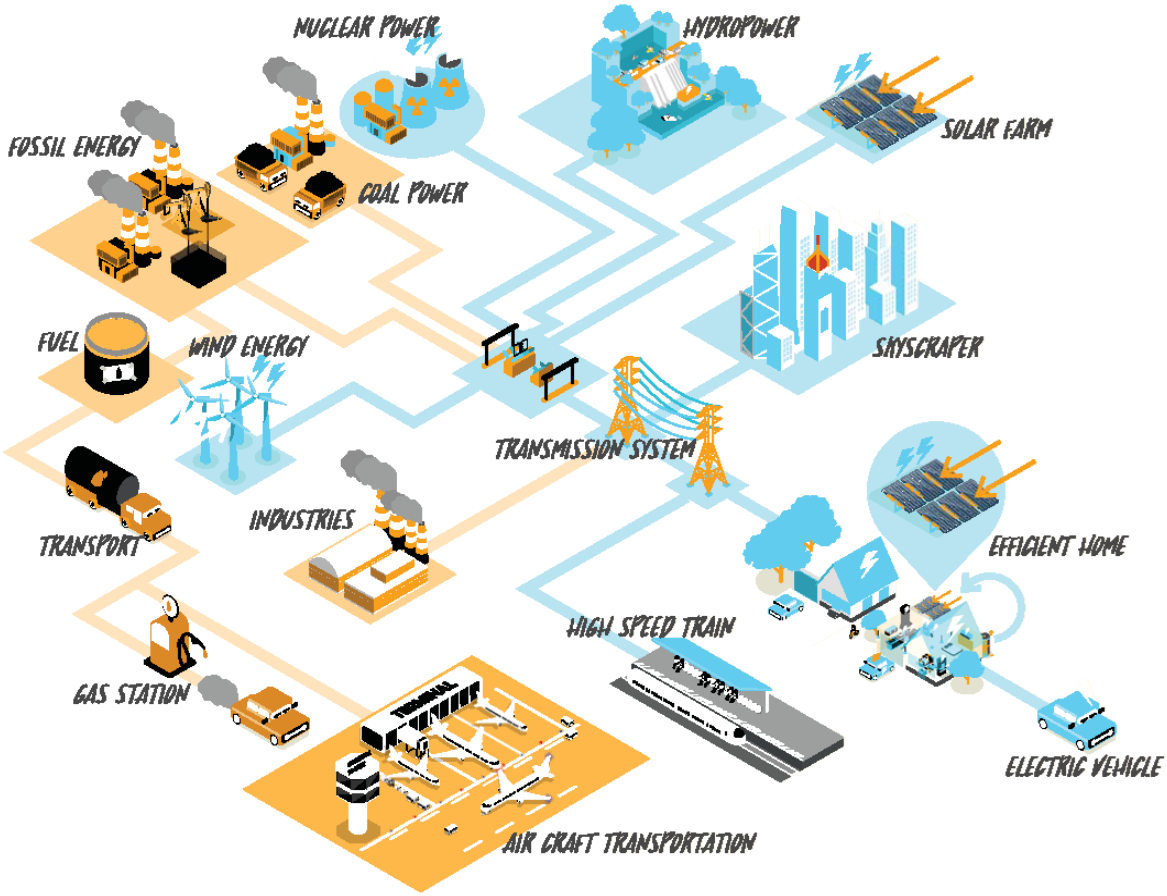
Energy affects every aspect of everyday activities, including our ability to power and heat our homes, fuel our vehicles, and interact with the regional economy. Indeed, energy issues touch the most personal and foundational aspects of our lives, while simultaneously carrying profound economic and environmental implications at the local, regional, state, national, and even global levels. This complexity necessitates a common understanding of the energy sources, uses, and losses in Franklin County.

We analyzed complex systems to understand the production and consumption of energy in Franklin County. For example, the energy used in Franklin County may be generated from sources such as fossil fuels, nuclear, and renewable energy and delivered from other regions via the electric grid (See Figure 1). A small fraction of it is produced in the county, but the majority of it is imported from other parts of Ohio or even farther away.

Multiple agencies and groups are responsible for providing energy to Franklin County customers. For more on the electric grid and energy transmission see the EIA's website[4].

[4] https://www.eia.gov/Energyexplained/index.cfm?page=electricity_delivery.

FIGURE 1: CONCEPTUAL MODEL OF OUR REGIONAL ENERGY SYSTEM



SOURCE ENERGY VERSUS SITE ENERGY

It is important to distinguish between ***site*** energy consumption and ***source*** energy consumption. Most often, energy consumption is measured as ***site*** or ***end use*** energy (i.e. that which is recorded at an electricity or gas meter or at the gas station pump).

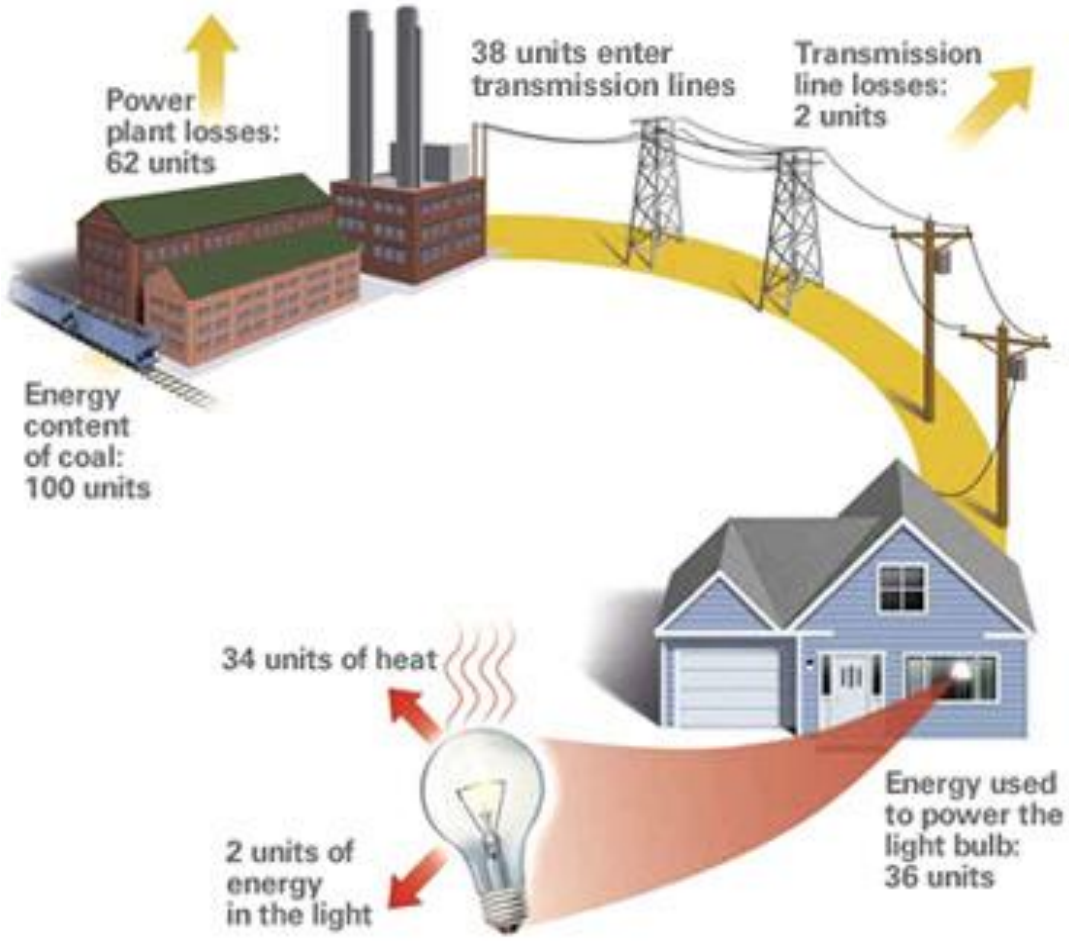
Source energy, as defined in this baseline[5], is a measure of the total primary energy that, in addition to site energy, also includes the energy lost or used in conversion, transmission and distribution of the energy supplied to the end user. Source energy is particularly relevant when measuring electricity energy supplied from a regional grid. Electricity generated from combustion (i.e. coal, natural gas, oil and biomass) typically loses more than half of its energy at the power plant in the form of heat (see Figure 2).[6] While modern combined-cycle plants may achieve greater efficiencies in lost-heat recovery, waste heat is not typically recovered in the process. Regardless, a significant amount of energy loss still occurs at the point of generation, even with generators that are considered more efficient. As a result, local stakeholders have little control over the energy losses from generation, conversion, transmission and distribution. This is particularly relevant for Franklin County, as most of the source energy is generated outside of the county and supplied by auctions controlled by the PJM Interconnection (see map in Figure 7).

Considering total, or source, energy becomes particularly important when making comparisons of environmental impact and when comparing the energy demands of on-site electrical generation versus the regional grid. For example, on-site generation may reduce transmission and distribution losses and increase opportunity for heat recovery from thermo-electric generation (i.e. co-generation or combined heat and power).

[5] In some instances, *source* energy may also include energy lost in the extraction, and refining of primary fuels, however, this information was not directly available through EIA's SEDS database nor used for the estimate of Franklin County energy consumption.

[6] Source: National Academies Press 2008 What You Need to Know about Energy

FIGURE 2: SOURCE ENERGY, SITE ENERGY AND ENERGY LOSS



End Use Categories to Classify Energy Use

In order to better understand where and how the county is using energy, consumed energy is broken down into four "end use" categories: residential, commercial, industrial and transportation (see Table 1).

Table 1: Community Activities in End Use Energy Sectors

End Use Sector	Energy Consumption Activities
Residential	All owner-occupied and rental housing, except for some multi-unit housing classified by utilities as commercial.[7]
Commercial	All public and private commercial, government and institutional facility operations, including generators and combined heat and power systems.[8]
Industrial	All facilities and activities production, processing, or assembling goods within each county. This encompasses manufacturing, agriculture, forestry, fishing, and hunting, mining (including oil and gas extraction) and construction.
Transportation	Energy associated with vehicular, rail, air, boating travel and transport of goods within the political boundaries of each county. Includes local, through-traffic, visitor travel, and pipeline transport of oil and gas products.

[7] Households in apartment buildings with individual meters that receive energy utility bills directly from the utility are typically categorized as residential, while households in apartment buildings with master energy meters for the entire building are categorized as commercial based on how the data is reported by the utility companies.

[8] Combined heat, and power (CHP) are facilities that generate both electricity and heat, typically for commercial or industrial heating or cooling purposes, resulting in increased efficiency.

Energy Types

The forms of energy consumption included in this baseline are all forms of energy reported through the EIA's State Energy Data System (SEDS) summarized in Table 2.

Table 2: Energy Types Consumed in End Use Sectors

Type Classes	Energy Types
Retail Electricity	Retail electricity purchased from the regional electric grid and consumed in homes, businesses, public facilities, industrial processes, and transportation
Onsite Renewable Energy	Solar, wind, hydro energy consumed for onsite electric production
Heat & Power Fuels	Natural gas, liquefied petroleum gases (including propane), distillate fuel oil, residual fuel, kerosene, coal, geothermal, and wood consumed for heating, and commercial and industrial combined heat and power. (Excludes retail electric power plant consumption)
Transportation Fuels	Motor gasoline, diesel (also distillate fuel oil), and aviation fuels.
Petroleum Non-Combustion Uses	Lubricants, asphalt, and road oils and other petrochemical products.

Baseline Glossary of Terms

In addition to the definitions and ideas above, below is a short glossary of terms used throughout this report.

Table 3: Baseline Glossary Terms

Term	Definition
Btu	British thermal units, a standard unit measure of energy or the heat content of a fuel or energy source. One Btu is the heat required to raise the temperature of one pound of water 1 degree Fahrenheit. All forms of energy and fuels can be expressed in terms of Btu and it is commonly used to compare the energy content of different energy sources. Energy values are typically reported in million or trillion BTU (mmBtu or TBtu).
CO_2e	Carbon Dioxide Equivalents, a standard unit of measure for gasses that contribute to the greenhouse effect. In addition to carbon dioxide, methane and nitrous oxide are typically expressed as their potential to cause global climate change relative to carbon dioxide - thus the combined contribution of the combustion gases can be expressed as total carbon dioxide equivalents. This is typically reported as $MTCO_2e$ or metric ton carbon dioxide equivalents.
End Use Losses	This is the energy wasted due to the inefficient use of energy. For example, the transportation end use losses include the heat generated by a gasoline-powered car as it sits idling in traffic.
Energy Use Intensity	A measure of how much energy is consumed by a building, community, or economic sector divided by some common metric that allows for benchmarking or comparing performance. Typical examples are mmBtu per capita, per household or per square foot of floor space.
Energy Productivity	A measure of how effectively a geographic region produces economic value from the energy it consumes – energy productivity is to an economy what miles per gallon is to a car. At the national or state level it is typically expressed as dollars of gross domestic product generated per million Btu of energy consumed. At the county level it is expressed as dollars of annual income generated per million Btu of energy consumed.
PJM Interconnection	PJM is a regional transmission organization that coordinates the movement of wholesale electricity through the electric transmission system serving all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and the District of Columbia.
Site Energy	Also known as end use energy, this is the energy that is recorded at the electricity or gas meter or at the gas station pump. Site energy can also refer to energy which is produced on-site or at the point of use.
Source Energy	Also known as primary energy, this term includes site energy plus the energy lost or wasted during extraction, conversion, transmission, and distribution of the energy supply form the regional grid.

Electric Generation Source Mix

A baseline study, by design, is meant to serve as a starting point from which to measure change. When considering improvements to the electric generation system for Franklin County, it is imperative to consider three important parts of that system: local generation, state generation, and the regional electricity market (PJM Interconnection).

Franklin County Generation

Franklin County has nearly 15 megawatts (MW) of generation capacity that is fueled primarily by petroleum, solar, biomass and wind. Despite almost 50 percent of generation capacity powered by renewable sources within county borders, Franklin County relies on electricity supplied from power plants throughout the state of Ohio and the PJM Interconnection to meet the demand of residents and businesses.

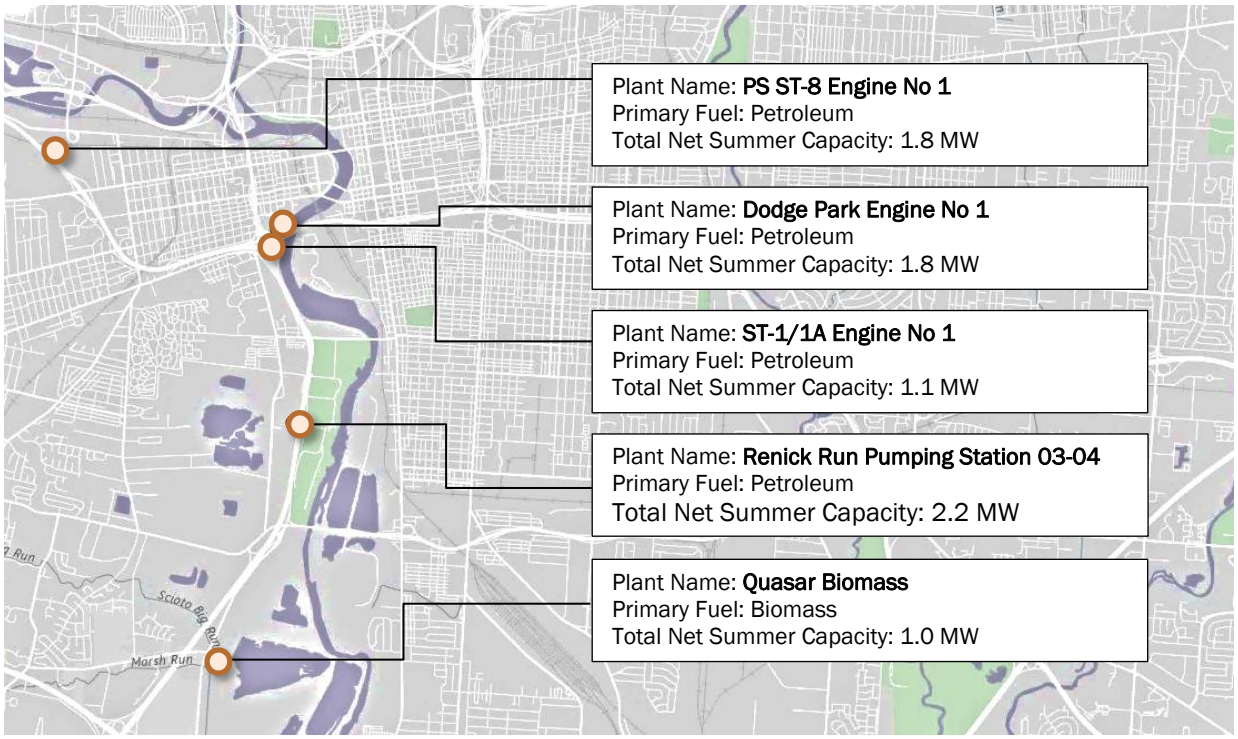
Currently, Franklin County has almost 7 MW of photovoltaic (PV) capacity, which on average, is sufficient to power over 700 homes.[9] With 165 MW installed in Ohio as of 2016,[10] Franklin County represents approximately 4 percent of the state's total PV capacity. Solar energy not only provides an emissions-free source for electricity, but when PV systems are installed on homes, businesses and in community arrays, it has the additional benefit of lessening the outflow of energy expenditures from Franklin County. Net-metering is available to Ohio residents and provides a valuable incentive to the growth of PV generation capacity in the region.

State Generation

Due to the way electricity is dispatched within the electric grid, Franklin County is most likely to be using the electricity generated closest to it, but not necessarily, as will be discussed in the next section. The mix of state generation, however, plays a large role in the air quality that is experienced by Franklin County. Emissions do not follow political boundaries and even though the electricity may be generated outside of the county, the county experiences some of the environmental impacts associated with its electricity demand. Calculating this impact would be valuable to investigate in future studies. The state generation profile is nonetheless worth noting as is provided in Figure 5.[11]

[9] According to the Solar Energy Industries Association: https://www.seia.org/initiatives/whats-megawatt
[10] https://www.seia.org/state-solar-policy/ohio-solar
[11] Ohio estimates from US EPA eGRID for 2010 and 2014 and SEDS for 2015.

FIGURE 3: UTILITY-SCALE GENERATION IN FRANKLIN COUNTY[12]



[12] From EIA (September 20, 2017).

FIGURE 4: SOLAR CAPACITY IN FRANKLIN COUNTY

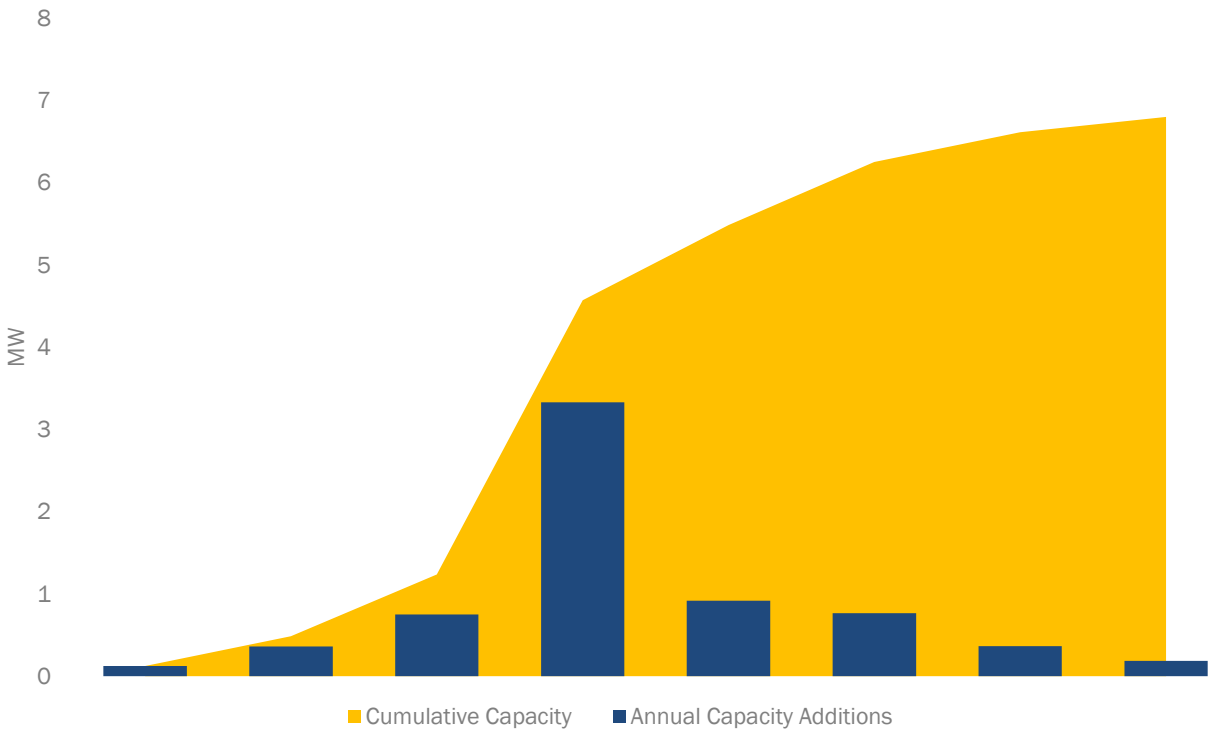
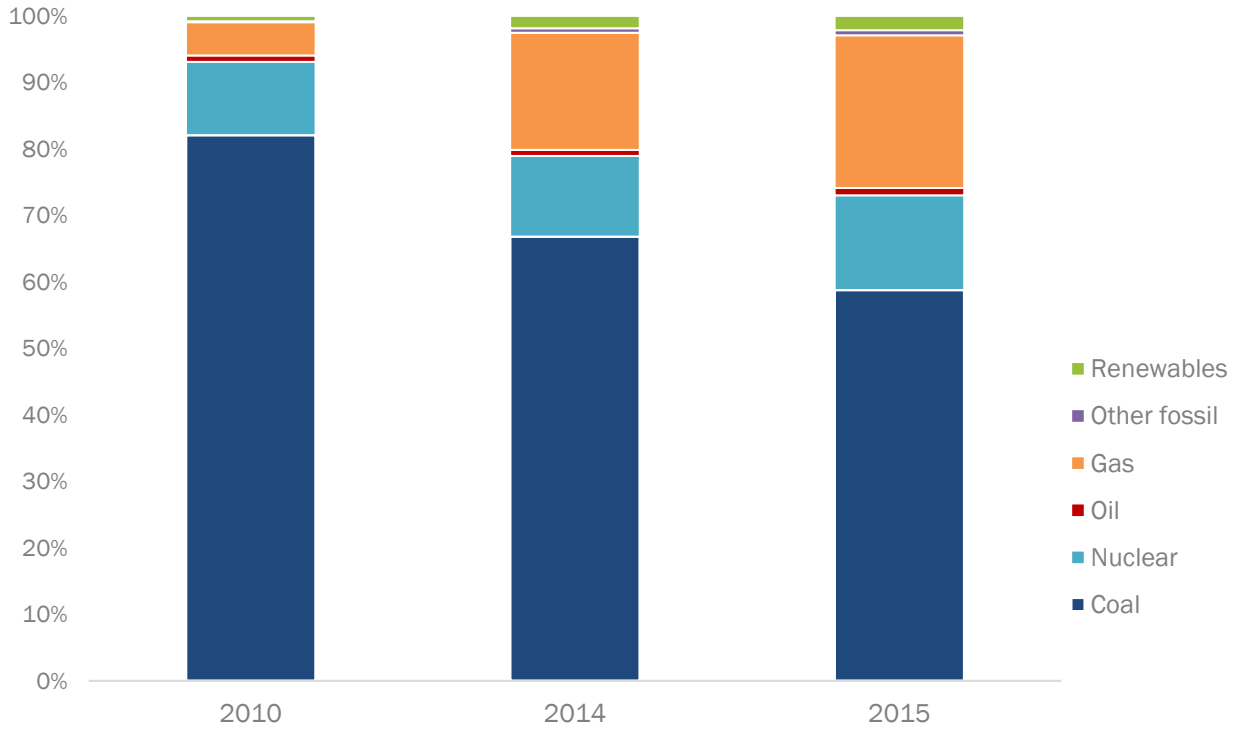


FIGURE 5: ELECTRIC GENERATION SOURCE MIX IN OHIO



The largest generating units proximal to and serving Franklin County are located in Conesville (coal, 1,530 MW), Dresden and Mt. Sterling (both natural gas, 540 and 435 MW respectively). Throughout the state of Ohio, in 2015, 59 percent of generation came from coal, 23 percent from natural gas, and 14 percent from nuclear. Renewables accounted for just over 2 percent of the generation mix, with the remainder being supplied by petroleum sources.

Regional Electricity Market

Ohio, and thus Franklin County, is a part of the PJM Interconnection, the regional electricity market that handles which power plants produce on any given day and the price they are paid for the electricity they create. Electricity generated within the PJM Interconnection can technically flow to any other area within the market region, or even to other markets connected to PJM. Since this report is meant to be a starting point from which to measure change associated with Franklin County, the generation and emissions profile of PJM are the standard by which we measure this impact. This approach of utilizing the regional interconnection for calculating emissions is the same protocol that is used by the City of Columbus as required for compliance in reporting emissions to the Global Covenant of Mayors for Climate and Energy.

The percentage of renewable energy and nuclear energy is much larger for the PJM mix than in the state of Ohio.[13] In 2015, coal supplied 37 percent of the generation mix, followed by nuclear (36 percent), natural gas (23 percent) and renewables (4 percent). Although comparative data for Ohio is not available for 2017, it is important to note that PJM Interconnection is gradually relying less on coal for electricity generation. This portion of the mix is being replaced by natural gas, and to a lesser degree, nuclear and renewables. In 2017, renewables accounted for over 6 percent of the generation mix, which represents a nearly 50 percent increase since 2015.

[13] Data from the PJM Interconnection.

FIGURE 6: ELECTRIC GENERATION SOURCE MIX FOR THE PJM INTERCONNECTION

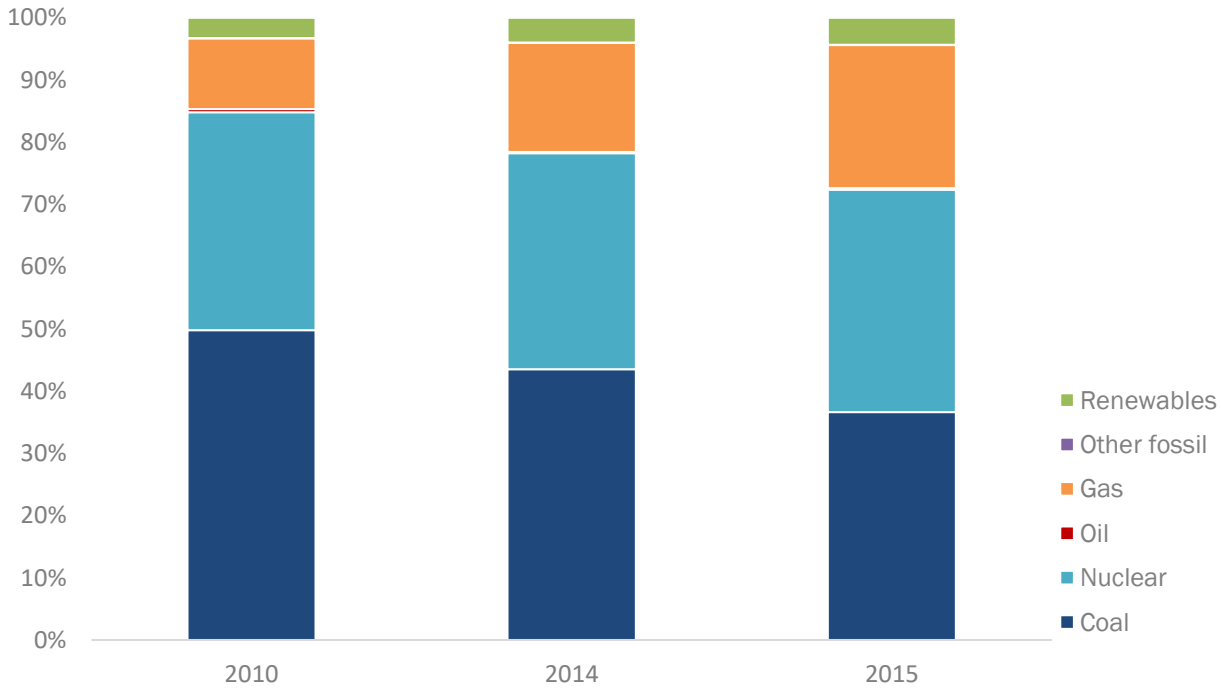
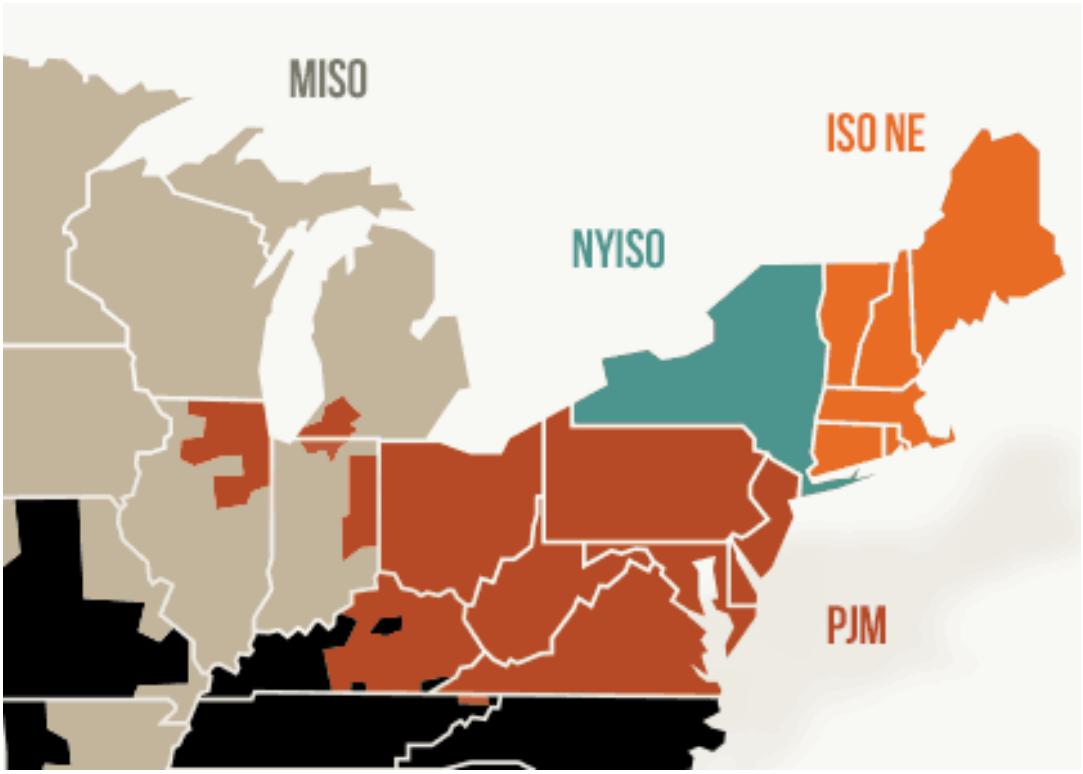


FIGURE 7: REGIONAL (PJM) ELECTRICITY GRID SERVICE TERRITORY



Demographics and Employment

Franklin County's population has grown by an average of one percent per year since 2000, an increase of more than 12,000 people each year. Since 2010, the county has added an average of more than 16,000 people annually.

Other demographic factors beyond population can influence the demand for energy and the potential cost burdens. Franklin County has a higher per capita income and smaller household sizes than the U.S. Another way to look at this would be more homes per person. This can increase the per capita energy consumption. Median monthly costs for homeowners are higher in Franklin County than in the U.S., but median gross rents are lower by almost the same amount.[14]

Franklin County has a higher labor force participation rate that translates to more energy consumption for work and travel. The average travel time to work in Franklin County is lower than the U.S. average but more of these commuters drive alone, which offsets the energy savings from a shorter commute.

Jobs have grown by an average of 0.3 percent per year from 2000 to 2016. The county has added an average of nearly 2,300 jobs each year since 2000 but growth accelerated with an annual average increase of more than 15,200 jobs each year since 2010. This rapid growth in population and jobs increases the demand for energy.

[14] 2015 U.S. Census Bureau, and U.S. Bureau of Labor Statistics, Quarterly Census of Wages.

TABLE 4: SELECTED DEMOGRAPHIC AND ECONOMIC INDICATORS[15]

	Franklin County	United States
Per Capita Income	$29,244	$28,930
Median Household Income	$52,341	$53,889
Persons per Household	2.47	2.64
Median Monthly Owner Costs (No Mortgage)[16]	$544	$458
Median Gross Rent	$845	$928
Labor Force Participation	69%	63%
Mean Travel Time to Work (Minutes)	21.6	25.9
Percent Who Drove Alone to Work	80%	77%

[15] U.S. Census Bureau, American Community Survey 2011-2015.
[16] From Factfinder.census.gov: Selected Monthly Owner Costs - Selected monthly owner costs are calculated from the sum of payment for mortgages, real estate taxes, various insurances, utilities, fuels, mobile home costs, and condominium fees. Listing the items separately improves accuracy and provides additional detail. When combined with income, a new item is created -- Selected Monthly Owner Costs as a Percentage of Household Income. This item is used to measure housing affordability and excessive shelter costs. For example, many government agencies define excessive as costs that exceed 30 percent of household income.

FIGURE 8 ANNUAL NET CHANGE IN POPULATION AND JOBS IN FRANKLIN COUNTY (2000 TO 2016)

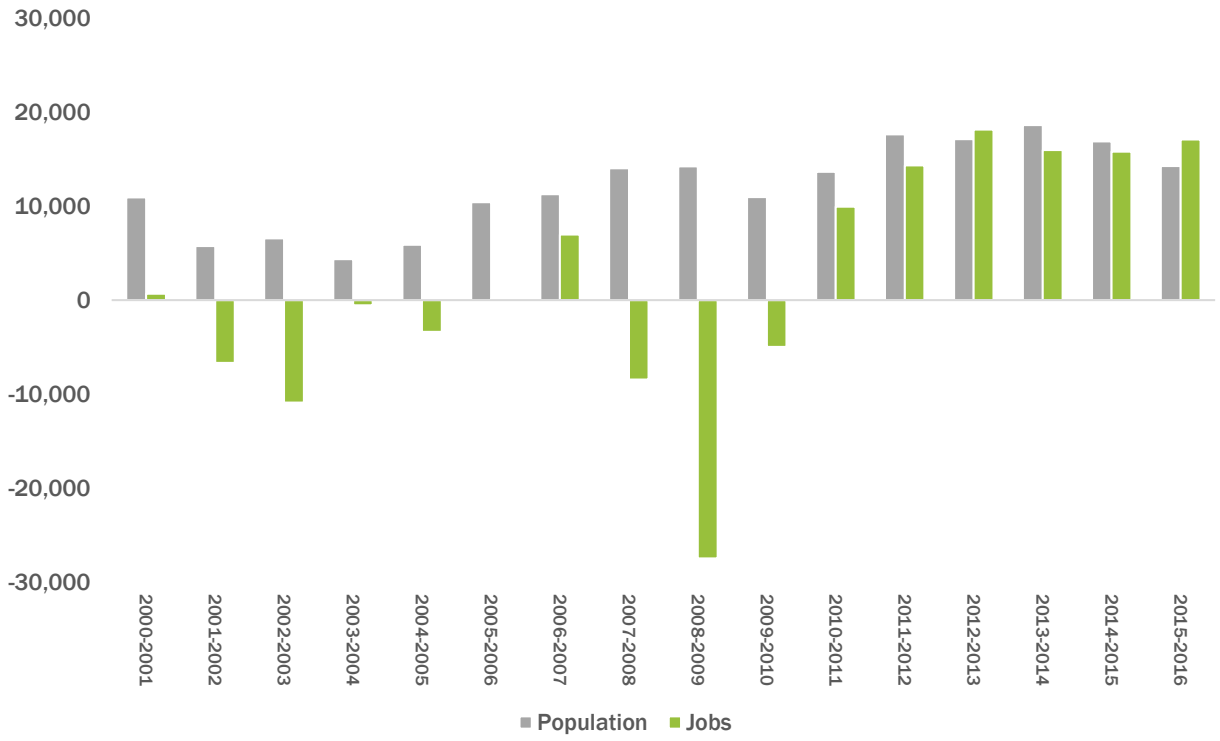
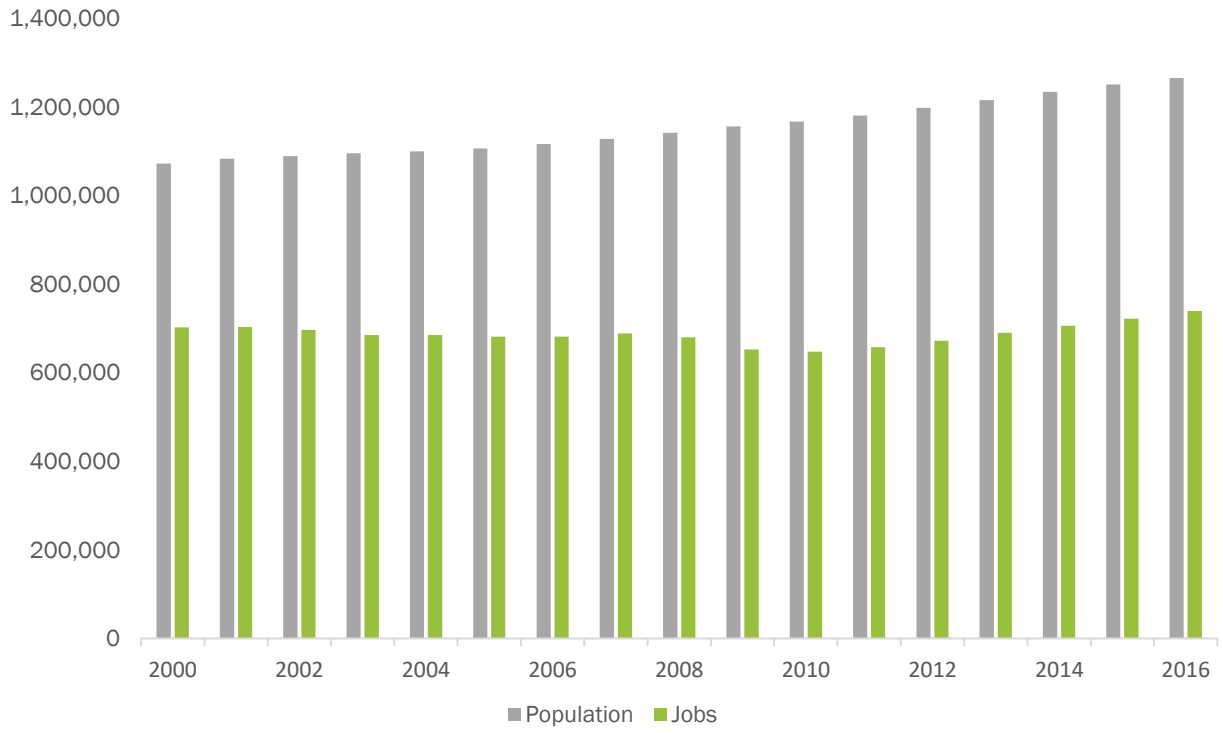


FIGURE 9: POPULATION AND JOBS IN FRANKLIN COUNTY (2000 TO 2016)



Franklin County Energy Sources and Uses – 2015

Consumption, Expenditures and Emissions

A detailed breakdown of the estimated county energy consumption across the end-use sectors as well as total expenditures and greenhouse gas emissions from energy use by energy type is provided in Table 5. Of the total $4.4 billion spent on energy in Franklin County, electricity and gasoline accounted for the majority of expenditures. Whereas the commercial sector uses the most electricity in the county, the residential sector is the greatest consumer of natural gas. The use of petroleum and natural gas were the greatest contributors to greenhouse gas emissions created in Franklin County.

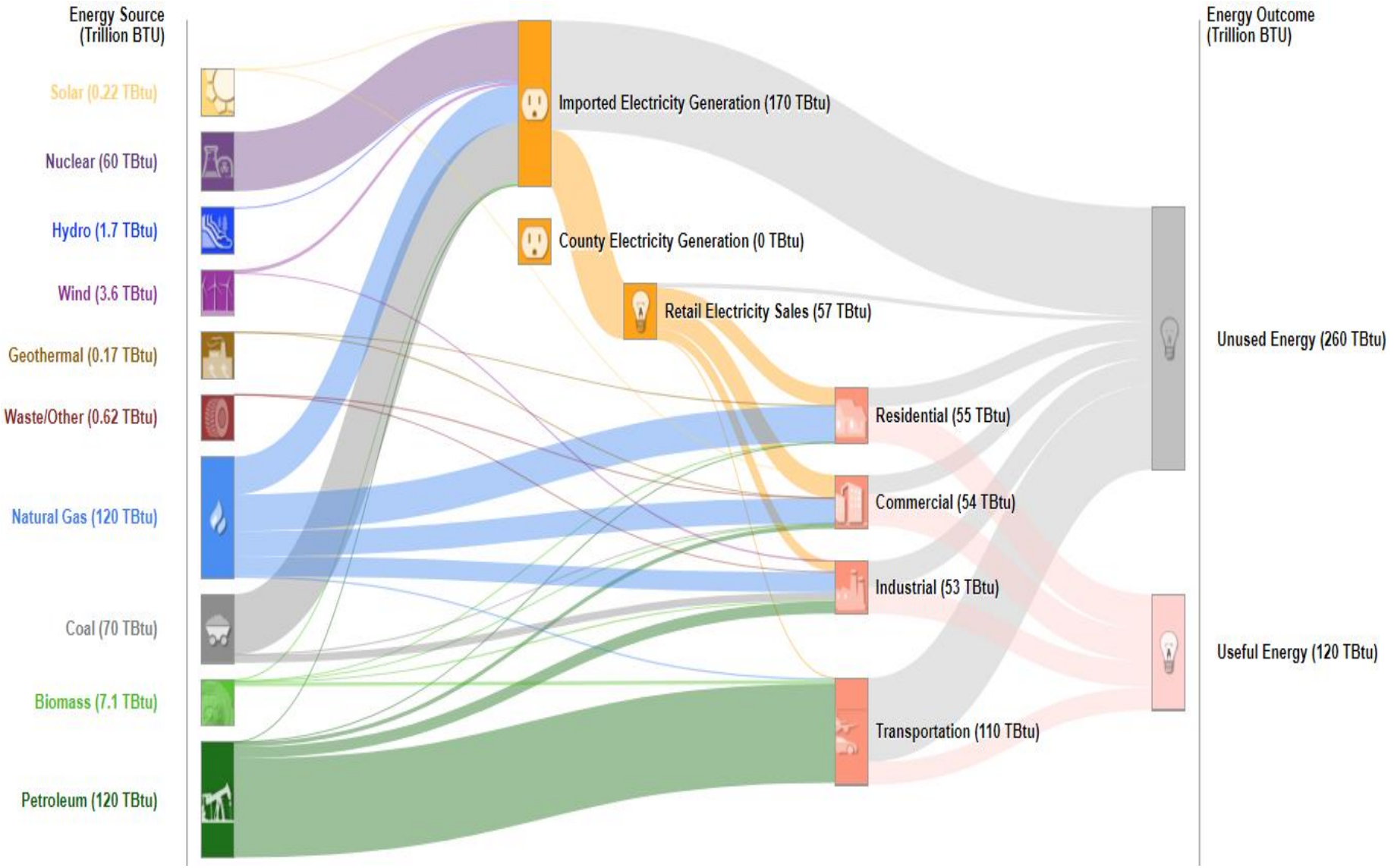
Figure 10 depicts energy flow in Franklin County, Ohio. On the left side of the chart, sources of energy are listed, including primary energy sources both generated within and imported into the county. Moving to the right, each source (indicated by a colored line whose thickness is proportional to the amount of energy) flows into various "energy conversion nodes," such as generated electricity and consumed energy for productive uses. On the right side of the chart is the energy outcome, highlighting energy used (light red) and unused (light grey) due to inefficiencies in energy generation, transmission, distribution and use. In the event Central Ohio were a net exporter, exports would also be shown along the top. Nearly 69 percent of energy is lost due to thermal conversion, transmission, distribution and end-use inefficiencies.

TABLE 5: FRANKLIN COUNTY END-USE CONSUMPTION, EXPENDITURES AND EMISSIONS (2015)[17]

Energy Type	Estimated County End-Use Energy Consumption					Energy Expenditure	GHGs from Energy Use
	Trillion Btu					Million 2015 $	1000 $MTCO_2e$
	Res	Com	Ind	Trans	All Sectors	All Sectors	All Sectors
Coal	0	<1	8	0	9	35	823
Natural Gas	37	25	20	2	84	603	4,463
Petroleum - Asphalt and road oil	0	0	2	0	2	29	0
Petroleum - Aviation Gasoline	0	0	0	<1	<1	3	10
Petroleum - Crude oil	0	0	0	0	0	0	0
Petroleum - Distillate Fuel Oil	<1	2	2	23	27	502	2,002
Petroleum - Kerosene	<1	<1	<1	0	<1	<1	<1
Petroleum - Kerosene-type jet fuel	0	0	0	23	23	273	1,670
Petroleum - LPG	<1	<1	<1	<1	1	27	76
Petroleum - Lubricants	0	0	<1	<1	2	101	112
Petroleum - Motor Gasoline	0	2	0	55	57	1,134	4,043
Petroleum - Residual Fuel Oil	0	0	<1	0	<1	2	13
Petroleum - Special Naphthas	0	0	<1	0	<1	18	0
Petroleum - Petroleum coke	0	0	2	0	2	2	156
Petroleum - Waxes	0	0	<1	0	<1	0	0
Petroleum - Still gas	0	0	3	0	3	98	199
Petroleum - Unfinished oils	0	0	0	0	0	0	0
Petroleum - Misc. products	0	0	<1	0	<1	3	0
Hydropower	0	0	0	0	0	0	0
Biomass - Wood	<1	<1	<1	0	2	0	0
Biomass - Waste	0	<1	<1	0	<1	2	0
Biomass - Fuel ethanol	0	<1	<1	4	4	<1	0
Wind	0	0	<1	0	<1	0	0
Geothermal	<1	<1	0	0	<1	0	0
Solar	0	<1	0	0	<1	0	0
Electricity Retail	18	23	11	<1	52	1,569	7,029
Total End-Use Energy	**55**	**54**	**52**	**110**	**270**	**4,402**	**20,596**
Electric System Losses	39	48	23	<1	110		
Total Primary Energy	**94**	**100**	**75**	**110**	**380**		

[17] 0 values in this table represent zero reported consumption, expenditure, or emissions. <1 values represent consumption, expenditures, or emissions that are greater than 0 but less than 1. Amounts may not total due to rounding.

FIGURE 10: FRANKLIN COUNTY ENERGY SOURCES, PRODUCTION, USE AND LOSSES (2015)



PRODUCTION

No significant amounts of petroleum, coal, or natural gas are produced within Franklin County due to either the availability of resources or local regulations. One well exists in Madison Township and produced 32 barrels of oil in 2015. With significant production occurring in the surrounding regions, Franklin County is, however, host to employment associated with energy production industries.

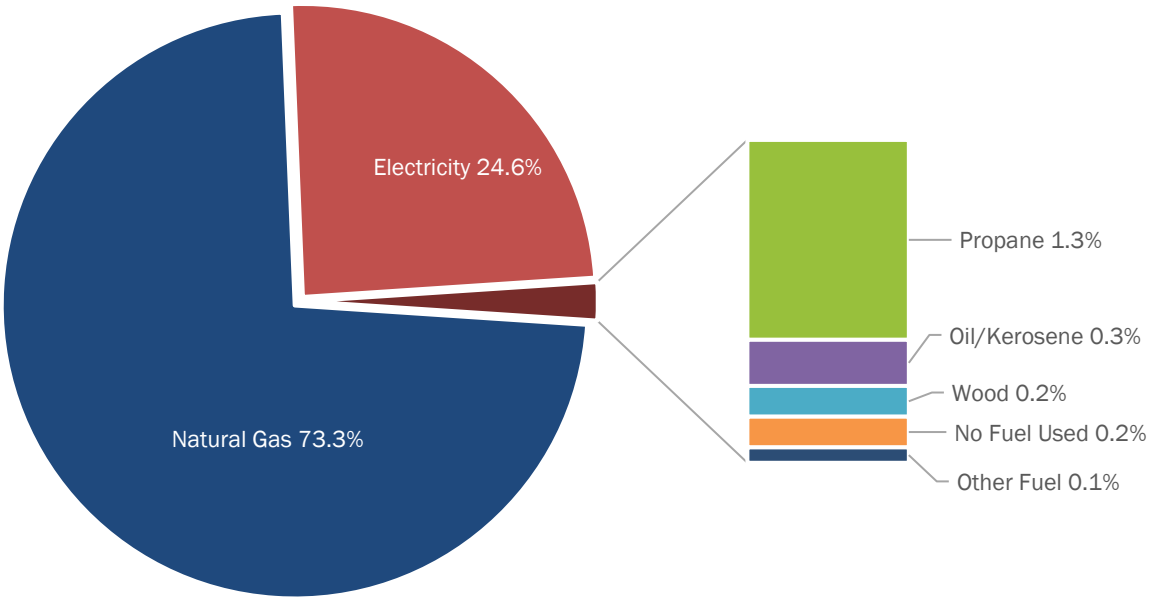
Renewable fuels such as solar, wind and biomass all provide direct and indirect employment as well as electricity and bio-based fuels within the county. Since they are in-county resources, they have the added benefit of reducing energy expenditure outflows from Franklin County. The production of energy from renewable resources continues to grow within the area. Photovoltaic capacity alone has experienced a 65 percent average annual growth rate since 2010 in Franklin County.

SOURCES FOR HOME HEATING

Homes in Franklin County primarily use natural gas (73 percent) and electricity (25 percent) for heating[18]. As both fuels can deliver heat at efficient rates, fuel switching does not present itself as a worthwhile endeavor to address inefficiencies or emissions. Updating furnaces and utilizing heat pumps could minimize wasted energy, but a more thorough study would be needed to identify the potential benefits.

[18] Census.gov, Fast Facts (accessed September 20, 2015)

FIGURE 11: HEATING SOURCES FOR HOUSEHOLDS IN FRANKLIN COUNTY (2015)



Energy Productivity and Efficiency

Overall Franklin County is productive in the energy it uses. As an energy importer, there is an economic interest in improving energy efficiency and reducing waste, which also reduces the outflow of dollars from the county. Table 6 breaks out end-use energy in useful and unused energy. Electric system losses are also part of unused energy. "Total Primary Energy" includes all of the useful and unused end-use energy as well as electric system losses.

In per capita terms, Franklin County has generally tracked with the United States for energy use per capita (Figure 12). In 2010, Franklin County used 325 mmBtu per capita compared to 316 mmBtu for the U.S. By 2015, Franklin County was using only approximately 300 mmBtu per capita versus 303 mmBtu for the United States.

Energy productivity provides another perspective on the energy efficiency of Franklin County. Energy productivity is measured as the dollars of economic output or income generated per unit of energy. In 2010, Franklin County underperformed the United States in terms of energy productivity, but in every year since, it has had higher levels of energy productivity.

Table 6: Franklin County End-Use, Useful and Unused Energy (2015)

Energy Use	Residential	Commercial	Industrial	Transportation	All Sectors
Total Useful Energy by Sector (TBtu)	36	35	25	25	121
Unused Energy by Sector	19	19	27	85	150
Total End-Use Energy	**55**	**54**	**52**	**110**	**270**
Electric System Losses	39	48	23	<1	110
Total Primary Energy	**94**	**100**	**75**	**110**	**380**

FIGURE 12: ENERGY USE PER CAPITA BY SECTOR (2010-2015)

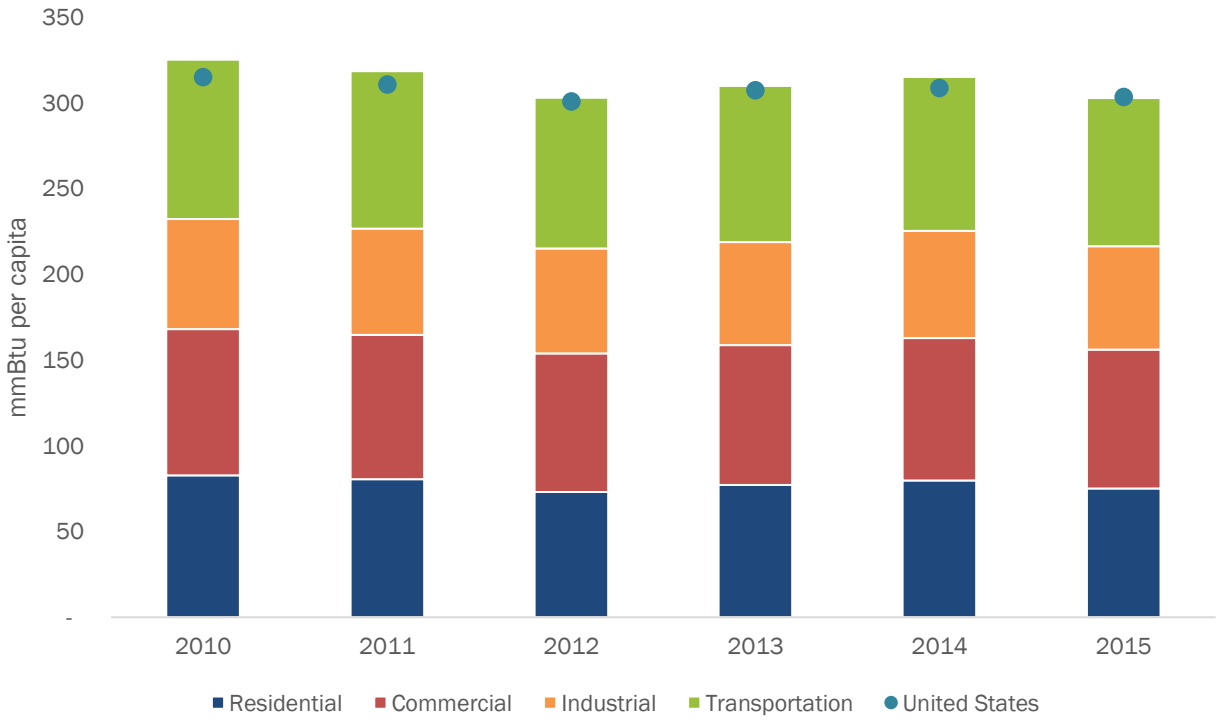
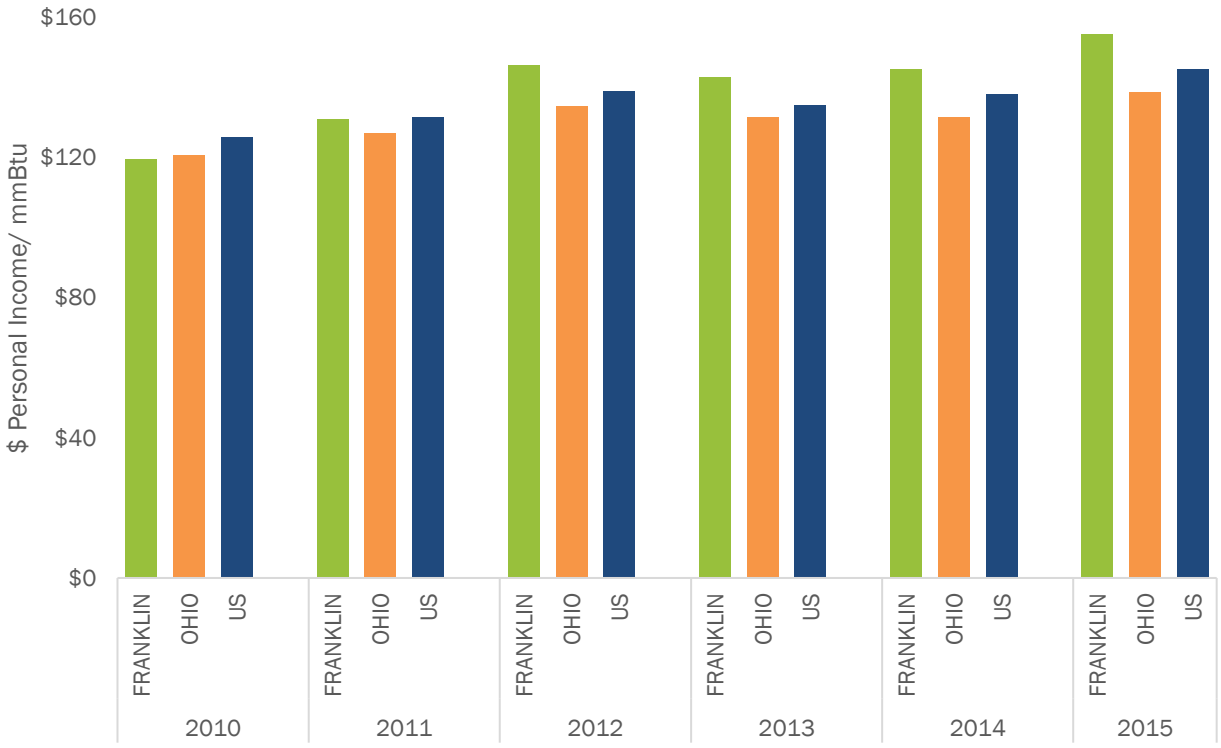


FIGURE 13: COMPARISON OF ENERGY PRODUCTIVITY (2010-2015)



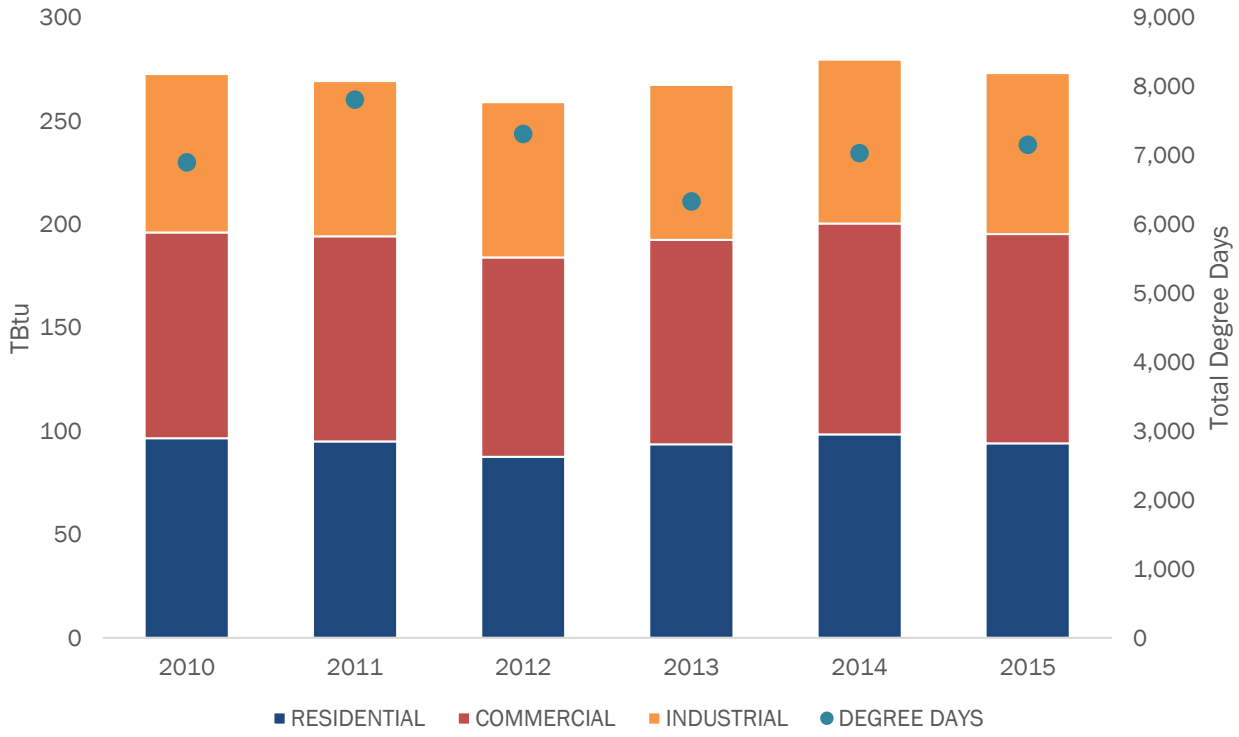
Until recently, energy productivity data have been relatively unavailable below the state level so comparisons to other counties and regions can be difficult. However, in 2014 the authors of this report completed a similar analysis for 32 counties surrounding Pittsburgh, Pennsylvania based on 2011 energy and economic data.[19] Allegheny County, like Franklin is to the Columbus Region, is home to the City of Pittsburgh, an international airport and about 1.2 million people in 2011. In that year Allegheny County had both a lower energy use intensity (306 mmBtu/capita) and a higher energy productivity ($165/mmBtu) compared to Franklin County (323 mmBtu/capita and $130/mmBtu, respectively), the difference may reflect the higher transportation energy use per capita.

Comparing differences in annual energy consumption and efficiency requires some consideration of how much heating or cooling needs may be different from year to year or place to place. Days that require heating or cooling are known within the energy sector as heating-degree days or cooling-degree days and are sometimes added together for total degree-days. The measure of degree-days provides a way to normalize energy consumption due to changes in annual weather patterns. Figure 14 compares annual residential, commercial and industrial energy use along with total degree-days per year. There is no clear trend that would credit Franklin County's improved energy efficiency or productivity to reduced demands for heating and cooling.

As 2015 will serve as the baseline from which change is measured in the future, 2015 data have not been weather-normalized in order to allow for appropriate weather-normalization in future comparison years.

[19] Sustainable Pittsburgh's Energy for the Power of 32 Final Report http://www.energy4p32.org/baseline.html

FIGURE 14: TOTAL CONSUMPTION BY SECTOR AND ANNUAL TOTAL DEGREE DAYS



ENERGY BASELINE BY ZIP CODE

In addition to this county level estimate, ZIP Code-level estimates were developed for each sector and energy type. Conducting this analysis at the ZIP Code level begins to reveal where energy cost burdens are the greatest. For this analysis, the study looks at residential energy expenditures which include spending on electricity and natural gas. Expenditures for transportation energy is not included.

Residential customers of the same utility pay the same amount per unit of energy. As such, the energy burden is primarily impacted by the quantity of energy used and the income of the household. Figure 15 contrasts each ZIP Code in Franklin County with the relative percentage of households below the poverty level in that ZIP Code. It may be no surprise that the highest energy cost burdens are in ZIP Codes with higher levels of poverty.

As shown in Table 7, the ZIP Codes with the highest energy cost burden tend to have comparatively low median incomes. There are instances where incomes play less of a role in the energy burden, and the age of home (and thus its energy efficiency) is a greater factor. This energy baseline provides a starting point for further discussion and analysis of energy use at a micro level.

The total energy use in each ZIP Code may be driven by population, commercial and industrial centers, or by transportation infrastructure. Analyzing the consumption by sector and ZIP Code offers an indication of where energy use is most intensive and areas that may be targeted for innovation, efficiency and savings. It is also important to understand which sectors are the greatest contributors to each ZIP Code's energy use intensity. For example, 43219 is the ZIP Code for the John Glenn Columbus International Airport and 43217 is the ZIP Code for the Rickenbacker International Airport, which explains the high energy use for transportation. This analysis provides a starting point, but does not answer all of the questions about what is driving energy consumption with different sub-regions of the county.

TABLE 7: MEDIAN HOUSEHOLD INCOME FOR ZIP CODES WITH HIGH ENERGY COST BURDENS

Area	Median Household Income	Average Annual Residential Energy Costs	Residential Energy Burden
43222	$21,083	$2,254	10.7%
43211	$23,710	$1,966	8.3%
43203	$20,904	$1,699	8.1%
43217	$34,769	$2,621	7.5%
43223	$29,167	$2,163	7.4%
43201	$25,322	$1,812	7.2%
43205	$30,491	$1,924	6.3%
43224	$33,487	$1,905	5.7%
43227	$34,483	$1,955	5.7%
43126	$39,375	$2,199	5.6%
43207	$38,842	$2,096	5.4%
43213	$34,610	$1,834	5.3%
43219	$33,473	$1,762	5.3%
43232	$36,425	$1,899	5.2%
Franklin County	**$52,341**	**$1,822**	**4.0%**

FIGURE 15: AVERAGE HOUSEHOLD ENERGY EXPENDITURES AS PERCENTAGE OF ANNUAL INCOME BY ZIP CODE (2015)

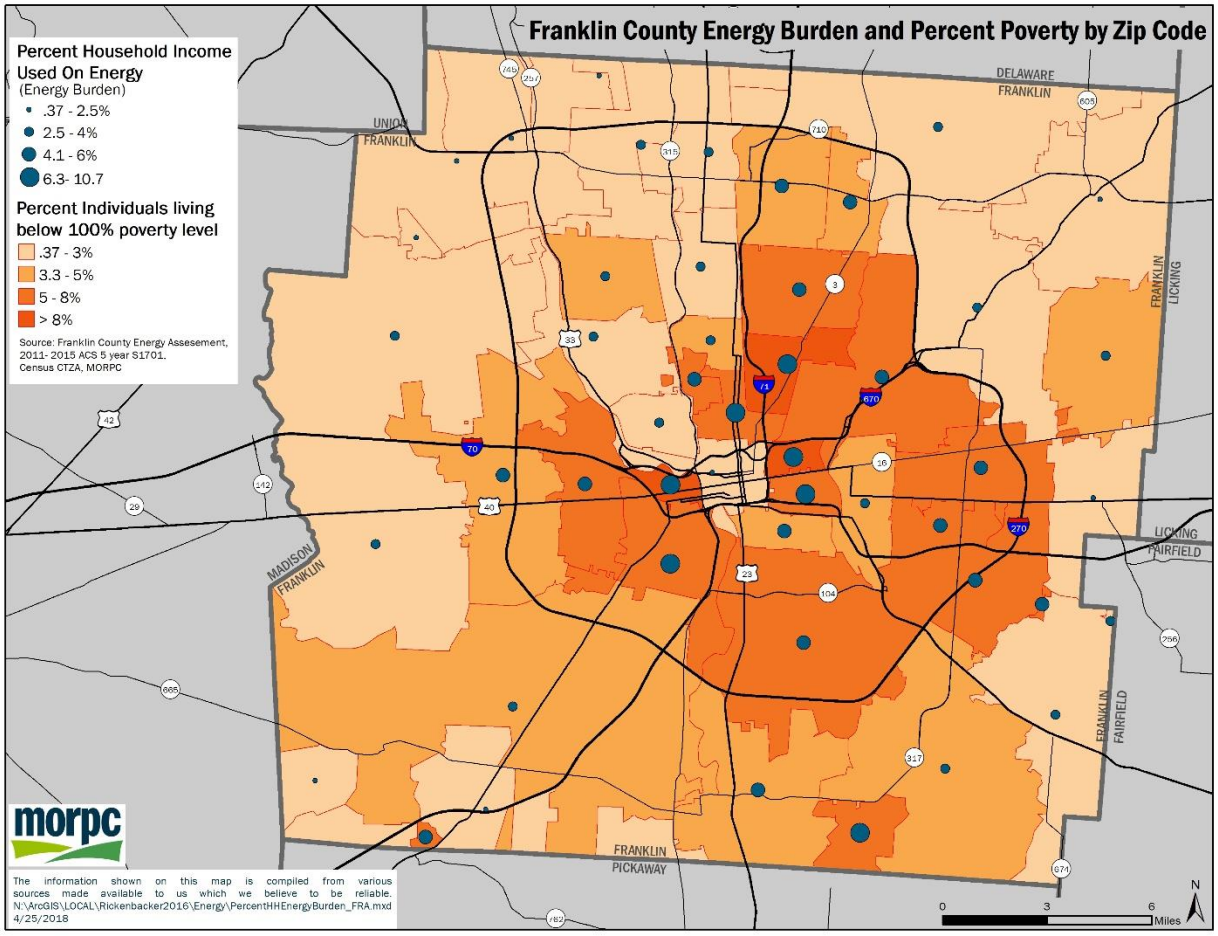


FIGURE 16: END USE ENERGY CONSUMPTION BY SECTOR AND ZIP CODE (2015)

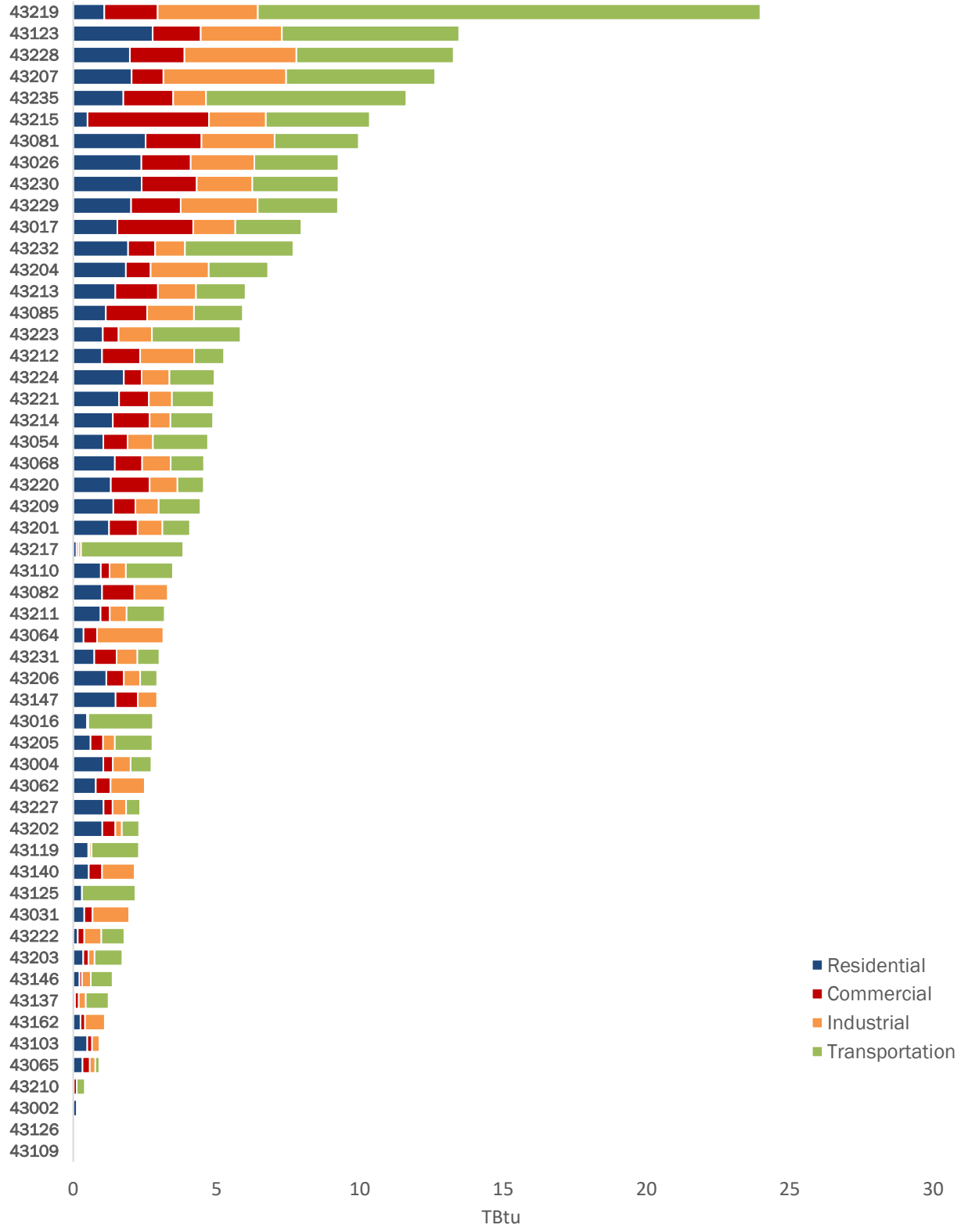
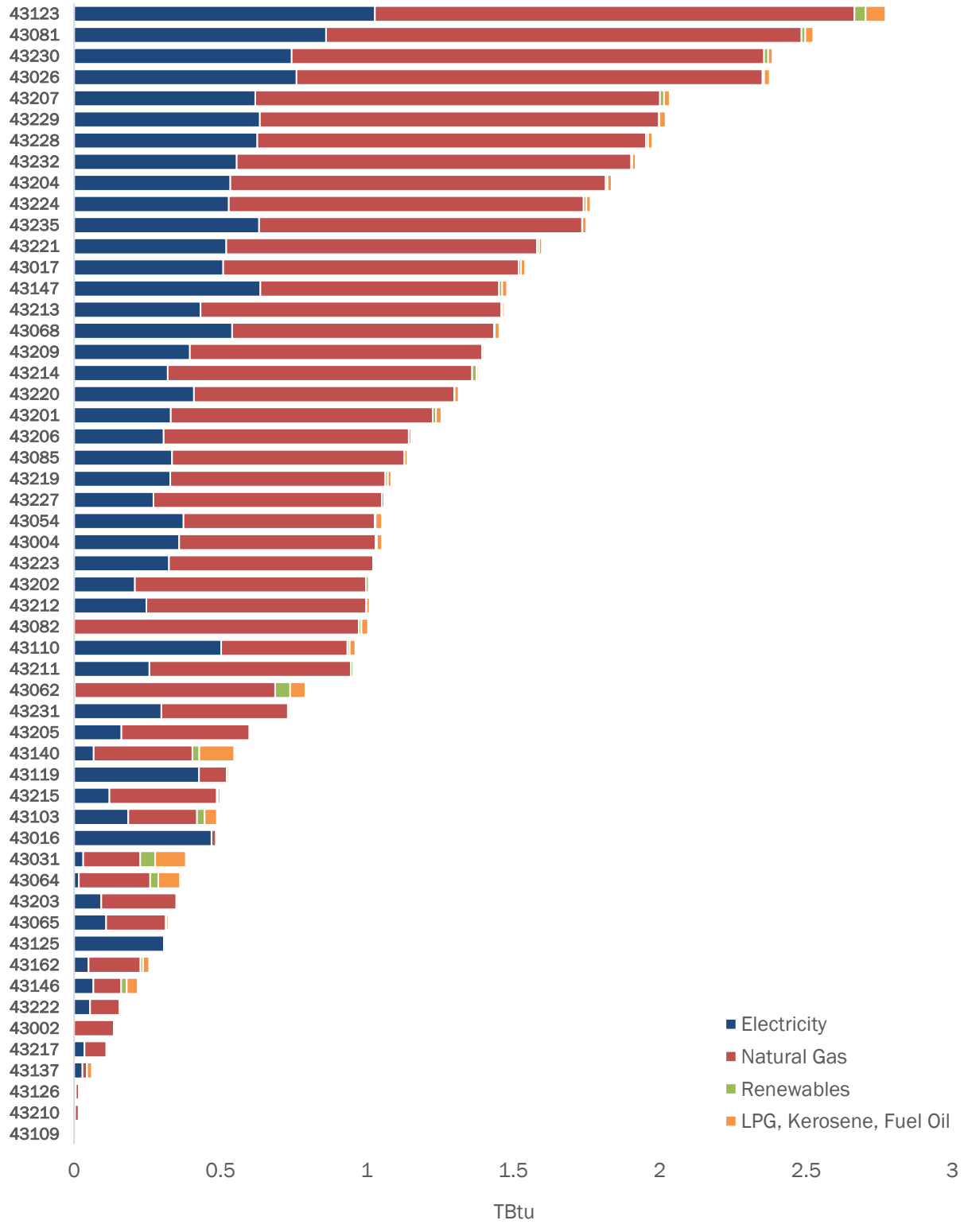


FIGURE 17: RESIDENTIAL END USE CONSUMPTION BY SOURCE (2015)



Franklin County Energy Initiatives

Accounting for every current effort to improve the energy system in Franklin County is a task larger than the scope of this study. It is important, however, to at least capture the general landscape of initiatives in the area.

Franklin County Resolution on Sustainability

In June of 2017, the Franklin County Board of Commissioners adopted a resolution recommitting the county to the promotion of environmental protection and sustainability. The resolution specifically addresses:

- Conservation of natural resources through energy efficiency in county operations
- Purchasing of energy generated from renewable sources
- Construction of high performance green buildings
- Design and development of sustainable neighborhoods
- Loan financing programs such as EnergyWorks
- Reducing emissions in county operations
- Support for the green energy economy including the preparation of the workforce for green jobs

EnergyWorks Program

In an ongoing partnership with the Columbus-Franklin County Finance Authority, the EnergyWorks[20] program provides loan financing to Franklin County businesses and nonprofit organizations for cost-effective, energy efficiency improvements. Designed to increase the energy efficiency of both existing and new facilities, EnergyWorks aims to lower energy costs, reduce carbon emissions and accelerate economic growth in Franklin County.

Property Assessed Clean Energy (PACE) is a financing method for efficiency improvements and renewable energy which has been adopted in many municipalities across the nation. In Franklin County, property owners may finance qualifying measures through future property tax payments. PACE's low-cost long-term financing options alleviate issues that hinder the adoption of advanced energy solutions, such as up-front costs and the ability to secure loans through traditional financing methods.

[20] https://development.franklincountyohio.gov/energy-works

In March of 2016, the Franklin County Commissioners announced the PNC Plaza EnergyWorks project in the City of Columbus. EnergyWorks provided a $400,000 PACE loan to assist with more than $3.3 million in energy efficiency upgrades to the 24 story PNC Plaza. The project includes green improvements to the 360,000 sq.ft. building's roof, lighting, and water supply and will provide energy savings of about 15%, reducing greenhouse gas emissions by more than 5,000 tons annually.[21]

SolSmart Designation

The SolSmart Designation is awarded to local governments which take action to improve the accessibility of solar power in their communities. In July of 2017, Franklin County was awarded the Bronze Tier designation for its efforts to improve soft costs related to permitting and inspection, as well as improvements to planning, zoning, and development regulations. Franklin County also received points for its community engagement initiatives and improving the marketplace through financing options. Franklin County is one of 17 counties in the nation to receive the designation and the first in Ohio.

For more information on the program, please visit:
http://www.gosparc.org/

Local Government Energy Partnership

The Local Government Energy Partnership is a collaborative effort between member communities and organizations of the Mid-Ohio Regional Planning Commission (MORPC) and the utilities that serve the area to create a sustainable region which reduces the costs of government, attracts businesses and encourages their growth, and lowers the energy burden on residents. With support from AEP Ohio and Columbia Gas of Ohio the Local Government Energy Partnership offers automated utility data collection to optimize energy usage, empowers local governments to become their community's trusted resource for energy efficiency programs, and assists them in reaching their energy goals and commitments.

Smart Columbus

Columbus competed against 77 cities nationwide to win the Smart City Challenge in 2016. The $40 million from the U.S. Department of Transportation was matched by $10 million from Vulcan, Inc. Towards decarbonization, Smart Columbus is working to modernize the electric

[21] https://development.franklincountyohio.gov/energy-works

grid through utility scale renewables, improve efficiencies and deploy smart meters. An effort is underway to place 780 electric vehicles into public and private fleets by 2020 and create a multi-modal approach to mobility options. To help make electric vehicles a real option for drivers, Smart Columbus is working to increase the amount of electric vehicle charging infrastructure.

For more information, please visit:
https://www.columbus.gov/smartcolumbus/home/

Utility Programs

Every utility serving Franklin County recognizes the importance of improving energy efficiency and provides incentives across all sectors to encourage energy conservation. As programs are added and improved frequently, the following table does not include specific programs, but provides a general perspective as to the options available to those who live and work in Franklin County. Residents and businesses are also able to take advantage of competitive pricing and renewable energy content choice through Energy Choice Ohio.[22]

Table 8 Energy Programs Available to Residential, Commercial or Industrial Customers

Program Category	AEP Ohio	Columbia Gas of Ohio	Columbus Division of Power	Ohio Edison	South Central Power	Westerville Electric Division
Advanced Metering	✓		(Coming in 2018)		✓	✓
Appliance Incentives	✓	✓		✓	✓	✓
Audit	✓	✓		✓	✓	✓
Demand Response	✓	n/a	✓		✓	
Low-Income/Senior Assistance	✓	✓	✓			
Industry Specific Incentives	✓	✓		✓	✓	✓

[22] http://www.energychoice.ohio.gov

NEXT STEPS

NOTE: At the request of the Advisory Committee, further analysis was conducted in order to develop a set of recommendations for Franklin County. Although the recommendations document is separate in order to maintain the objectivity of the baseline, it is expected to be released concurrently with the Franklin County Energy Study.

The baseline suggests some areas of opportunity and concern about Franklin County's current and future prosperity and security. It also represents a foundational step toward developing and implementing a strategic and proactive regional energy plan. To that end, it is recommended that the analysis be extended to:

- Examine what is driving the current trends to determine if recent improvements in energy productivity are sustainable and where additional capacity for improvement exists;
- Engage the public and stakeholders in a more informed dialogue about energy production and consumption and how to maximize the return on investment from choices on future development; and;
- Complete a detailed analysis of energy efficiency and productivity potential for different sectors of the economy.

There are also several policy and planning implications raised by the baseline analysis that will require further exploration:

- **Tackle the unused energy "elephant in the room"** – Like most of the nation, less than half of the primary energy consumed by Franklin County homes, cars, trucks, business, institutions, etc. is actually put to productive work – the remainder is lost as unused energy. The largest fraction of unused energy is lost at thermoelectric power plants outside of the direct control of the county. Even so, there are a number of potential strategies for addressing unused energy across all of the end-use sectors including:
  - Promoting and offering incentives, technical assistance and leadership support for energy efficiency and conservation in homes and businesses. Energy efficient lighting, insulation, energy-aware behavior policies, and smarter heating, cooling, and lighting controls not only reduce unused energy losses from where we live and work, but also reduce the need for the construction of new power plants in the region or for less efficient "peaker" power plants to be brought online to keep the power grid supplied during periods of peak demand.
  - Facilitating local renewable energy production can similarly reduce demand on regional thermoelectric power plants, as well as reduce losses in regional transmission by producing

energy at or near the point of use.

- Identifying and planning for combined heat and power (CHP) opportunities – can actually put unused energy to work. Targeting clusters of high electricity and heating/cooling demand or by developing new energy districts, local CHP plants produce electric power and effectively utilize the waste heat for heating and/or cooling in buildings or industrial processes nearby.

Transportation is the region's second largest contributor of unused energy. The internal combustion engine and drivetrain of typical of gasoline and diesel-powered cars and trucks is capable of converting only about 20% of the energy it consumes to the work of moving the vehicle (well-to-wheel efficiency) compared to electric motor powertrain vehicles that achieve approximately 60% well-to-wheel efficiency. Two key strategies for reducing transportation energy losses include:

- Facilitating transportation electrification, including personal cars, fleet vehicles, and public transit, through education, demonstration, charging facility planning, and incentivizing parking/charging stations; and
- Reducing vehicle miles traveled through smarter land use and infrastructure planning that increases access to employment, essential services, and retail by walking, biking, and public transit.

- **Leverage Existing Energy Action Efforts –** Explore how major local initiatives such as insight2050 and Smart Columbus can help to improve energy efficiency and productivity. Franklin County currently has 85 TBtu of unused energy in the transportation sector, enough energy for the annual consumption of 1.4 million cars. Changes to development patterns and land use modeled by insight2050 and promotion of electric vehicles and other new transportation

PITTSBURGH'S DECARBONIZATION AND ELECTRIFICATION STRATEGY

In 2014 the Power of 32 Region, comprised of 32 counties in four states surrounding Pittsburgh, PA developed an energy and emissions baseline to serve as a foundation for smart energy planning. The resulting baseline energy flow revealed both the vast fossil energy wealth and energy waste in the region. Multiple governmental, institutional, and organizational energy planning efforts have built their strategies from the baseline's insights on unused energy, including the City of Pittsburgh's most recent Climate Action Plan. A critical piece of the plan is to tackle unused energy through its four-pronged "Decarbonization and Electrification Strategy" to (1) reduce demand for energy, (2) create efficient district energy systems, (3) install local renewable energy generation, and (4) convert systems from combustion to electrification. Under this strategy, the City aims to control of the energy it consumes by identifying opportunities to produce it locally and renewably and use it to electrify energy smart development and transportation. Pittsburgh has established measurable goals of converting all City operations and 25% of Pittsburgh electricity consumers to 100% renewable electricity and reducing transportation emissions by 50% by 2030, to establish Pittsburgh as regional beacon of renewable energy innovation and community resilience.

technologies driven by Smart Columbus could have significant impacts on energy consumption, emissions and energy losses.

- **Invest in a localized energy economy** - Franklin County has reduced its energy use per capita and increased its energy productivity. However, because the county imports almost all of its energy, the local benefits from that spending are limited. The county can reduce this outflow through a variety of strategies:
  - Invest in local energy efficiency projects that create local jobs and keep dollars within county;
  - Promote technologies and industries that are part of energy efficiency and renewable energy solutions;
  - Assist in the development of local energy production where it aids locals' energy productivity and resilience.
- **Balance household energy burden inequities** – Lastly and importantly, the baseline indicated a number of communities within Franklin County are experiencing high household energy burdens. The national median share of income that U.S. households spend on energy is 3.5 percent. Nationally low-income households spend more than 7 percent of their income on energy.[23] Franklin County can do little to address market-level energy costs especially for energy produced outside its borders. However, Franklin County can target energy efficiency outreach and energy assistance programs to those areas with the highest household energy burdens, thus effectively reducing costs for those households.

BALANCING ENERGY BURDENS IN MICHIGAN

When the counties surrounding Grand Traverse Bay, Michigan completed their first energy baseline in 2012 they were struck by the wide disparity in median household energy burden across their region. The regional council of governments, chamber of commerce, and area non-profits partnered on focused outreach and targeted energy efficiency programs. One weatherization assistance program in Traverse City, TC SAVES, achieved national recognition for participation and energy savings by focusing outreach at the individual neighborhood scale. They used neighborhood "energy sweeps", engaging neighborhood organizations and placing yard signs in front of homes of participants to leverage the local social network. These actions helped to normalize the use of the program and encourage energy savings with the neighborhood. They found this to be more effective than aiding a scattered distribution of individual households. Recognizing that areas of high energy burden often occur in clusters of poverty such a strategy could prove effective in a targeting zip codes with proportionally high energy burden.

[23] See National Resources Development Council, Study Highlights Energy Burden for Households, and How Energy Efficiency Can Help, April 20, 2016. Available from https://www.nrdc.org/experts/khalil-shahyd/study-highlights-energy-burden-households-and-how-energy-efficiency-can-help.

APPENDIX

A - Methodology

B - Data

Energy Flow Diagrams 2010-2015
End-Use Consumption Tables 2010-2015
Total Energy Consumption by ZIP Code Maps 2010-2015
Energy Consumption by End Use Sector & ZIP Code Maps 2010-2015

APPENDIX A - METHODOLOGY

The value of completing an energy baseline is reflected in several nationally and internationally recognized guides for energy management and greenhouse gas emissions quantification.[24] These guides have been developed to ensure that each assessment is as complete, accurate and detailed as practical; allowing for effective decision making and comparability and avoiding double-counting of emissions. The most relevant nationally-accepted guidance for counties, cities, villages, townships and multi-county regions is the U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions (Community Protocol).[25]

As a minimum, the Community Protocol requires that communities include the following energy consumption activities based on the rationale that local governments can influence energy use associated with these activities through building codes, land use regulations, financial incentives, minimum regulatory requirements, infrastructure investments, technical assistance and other programs:[26]

1. Use of Electricity by the Community (including Residential, Commercial and Industrial Sectors)
2. Use of Fuel in Residential & Commercial Stationary Combustion Equipment (including Industrial)
3. On-Road Passenger and Freight Motor Vehicle Travel
4. Use of Energy in Potable & Wastewater Treatment

In addition, communities interested in understanding their regional position with respect to energy and emissions may also wish to evaluate energy production. However, standardized protocols for reporting energy production at a county or regional level have not been developed.

Collecting and compiling energy use and production data from utilities and producers for all energy types at a local or regional level is often not practical or feasible. Electricity and natural gas utility sales data are typically the only data that are feasible to collect at the local-level from individual utilities. The consumption of the remaining energy types generally must be estimated.

Regional non-renewable primary energy production and retail electric generation within Franklin County were compiled directly from county-level coal, oil and gas data reported publicly by the Energy Information Administration (EIA) and Ohio Department of Natural Resources. Regional energy production from renewable energy sources were estimated from retail electricity sales reported by the EIA, end-use consumption estimates and source energy factors published by the National Renewable Energy Laboratory.

The EIA does not provide energy consumption or expenditures at a resolution suitable for direct county or zip code-level energy use analysis and thus regional energy use and costs must be either collected from the region's energy utility providers or estimated. The EIA's State Energy Data System (SEDS) reports annually the end-use energy consumed and associated expenses paid by the four primary sectors (residential, commercial, industrial and transportation) in each state for most marketed forms of energy consumed in the U.S. This information is reported with a two-year lag, such that data representing the 2010 calendar year were reported in 2012 and so on.

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[24] The World Resources Institute - GHG Protocol publishes standards for corporate and community greenhouse gas emissions quantifications. http://www.ghgprotocol.org/standards

[25] Local Governments for Sustainability (ICLEI) publishes standards for local government and community GHG emission inventories. http://www.icleiusa.org/tools/ghg-protocol

[26] ICLEI Community Protocol also includes a 5th emissions generating activity, solid waste management, which is typically outside the scope of a regional energy baseline assessment.

TABLE 9: DATA SOURCES, ESTIMATES & ASSUMPTIONS

Data Source	Local Energy Utility Provider Data[A]			Energy Information Administration - State Energy Data System (EIA SEDS[B]), 1960-2015					ODNR[C],
Data Type	Electric & Natural Gas End-Use Consumption			All Other End-Use Consumption (Propane, Gasoline, Fuel Oil, Coal, Wood, & Other Fuels)					Energy Production	Energy Production
Sector	Industrial Activity	Commercial Buildings	Residential Buildings	Industrial Activity	Commercial Buildings	Residential Buildings	Transport - Road & Nonroad Activity	Transport - Airport Activity	Coal & Electric Power Production	Oil & Gas
Spatial & Temporal Resolution	Combination of Zipcode Data and County Data Downscaled to Zipcode, Monthly			State Level Data Downscaled to Zipcode, Annual					Latitude/ Longitude, Annual	Township, Annual
Downscaling Factors & Data Source	CBP[D]: # of Employees, Payroll, and # of Business Estab.	CBP[D]: # of Employees, Payroll, and # of Business Estab.		CBP[D]: # of Employees, Payroll, and # of Business Estab.	CBP[D]: # of Employees, Payroll, and # of Business Estab.	ACS[D]: Occupied HH by Primary Heating Fuel*	ODOT[E]: VMT& MORPC[F] Road Lane Miles*; Population	FAA[G]: Airport Takeoffs / Landings*, Population		
Source Energy Factors	Electricity – EIA SEDS[B] Electric Power Losses;									
End Use Energy Loss Factors	Lawrence Livermore National Laboratory 2015 Energy Flow Chart Technical Documentation (2017 Revision)[H]									
GHG Emission Factors	Electricity – PJM[I] (2012-2015) - CO_2; RGGI[J] (2010-2011) - CO2; US EPA eGRID[K] (1996-2014) – CH_4, N_20; All other fuels – US EPA Climate Leaders[K] – CO_2, CH_4, N_20									
Retail Energy Prices	EIA SEDS[B] (in nominal $USD)									

[A] Local electric and natural gas utilities representing approximately 90% of the county's service area provided retail energy sales by zip code or county. Missing

[B] EIA SEDS – Offers complete state-level energy consumption, expenditures, and production by sector, source for years 1960-2015. https://www.eia.gov/state/seds

[C] Ohio Departments ofDNR – Offers total oil and gas produced by township. Boundary twps' data is proportionally attributed based on on land area. http://oilandgas.ohiodnr.gov/production

[D] County Business Patterns (CBP) – Offers numbers of business establishments and employees and total payroll by county and American Community Survey (ACS) – Offers population (pop.) number of occupied households (HH) by primary heating fuel type, by county. Both CBP and ACS may be accessed at https://factfinder.census.gov

[E] Ohio Departments of Transportation (ODOT) – offers VMT (vehicle miles traveled by county and road functional class) https://www.dot.state.oh.us/Divisions/Planning/TechServ/TIM/Pages/VehicleMiles.aspx

[F] VMT is attributed to zip codes tabulation areas by GIS lane miles by functional class available from the Mid-Ohio Regional Planning Commission (MORPC) at http://morpc.org/data-maps/index

[G] Federal Aviation Administration (FAA) – Offers airport operations data for takeoffs and landings by airport. https://aspm.faa.gov/opsnet/sys/Airport.asp

[H] Lawerence Livermore National Laboratory – US Energy Flow Charts and technical documentation are available for years 2010-2016. https://flowcharts.llnl.gov/

[I] PJM has reported annual average, on-peark marginal, off-peak marginal CO2 emissions for years 2012 through 2015. Annual average was used for this study. http://www.pjm.com/~/media/library/reports-notices/special-reports/20160318-2015-emissions-report.ashx

[J] Regional Greenhouse Gas Initiative (RGGI) – Published estimated CO2 emission rates for the electric grid operators serving the and Mid-Atlantic states including PJM for the years 2010 and 2011. http://www.rggi.org/docs/Documents/Elec_monitoring_report_2012_15_08_11.pdf

[J] US EPA eGRID – Publishes average, baseload, and non-baseload GHG emissions rates biannually including CO2, CH4, and N2O. Annual average CH4 and N2O was used for this study. https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

[K] US EPA Climate Leaders – Publishes emission factors by energy source and carbon dioxide equivalence factors for CH4 and N2O for use in their voluntary reporting program. https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub

This state-level data may be downscaled to the county level to provide a reasonable estimate of regional energy consumption, expenses and emissions by sector and by source. For instance, county-level residential fuel oil consumption can be downscaled as a proportion of state-wide households using fuel oil as their primary heating source based on state-level residential fuel oil consumption data from SEDS and the number of occupied households in each county using fuel oil as their primary home heating fuel as estimated by the U.S. Census Bureau's American Community Survey.

Unused Energy

End-use and retail electric generation losses were derived using the methodology employed by the Lawrence Livermore National Laboratory (LLNL) in the creation of its national energy flow charts. Energy losses from the region's retail electricity generation sector are calculated by subtracting the net electricity generation sales from total fuel consumption. Energy losses from the region's end-use sectors are estimated with the national efficiency factors provided by LLNL. The energy loss totals are uniquely regional due to regional patterns of electric generation, transmission and distribution, as well as and regional energy consumption.

Energy Use Emissions

Scope 1 and 2 greenhouse gas (GHG) emissions have been estimated by multiplying energy consumption by an emissions factor representing the average quantity of GHG emissions emitted per unit of end-use energy consumed. Emission factors employed in this assessment were selected from those reported in the PJM 2015 Annual Emissions Report for retail electricity consumed within the region and the EPA's Climate Leaders[27] program for all other energy uses.

[27] US EPA – Corporate Climate Leadership program publishes a standard for organizations to voluntarily inventory and report their GHG emissions. http://www.epa.gov/climateleadership/guidance/index.html

APPENDIX B – DATA

CONSUMPTION TABLES

TABLE 10: END-USE CONSUMPTION TABLE (2014)

Energy Type	Estimated County End-Use Energy Consumption					Energy Expenditure	GHGs from Energy Use
	Trillion Btu					Million $	1000 $MTCO_2e$
	Res	Com	Ind	Trans	All Sectors	All Sectors	All Sectors
Coal	0	<1	9	0	9	38	885
Natural Gas	39	28	21	2	90	740	4,773
Petroleum - Asphalt and road oil	0	0	2	0	2	28	0
Petroleum - Aviation Gasoline	0	0	<1	<1	<1	5	11
Petroleum - Crude oil	0	0	0	0	0	0	0
Petroleum - Distillate Fuel Oil	<1	2	2	24	28	766	2,096
Petroleum - Kerosene	<1	<1	<1	0	<1	<1	1
Petroleum - Kerosene-type jet fuel	0	0	0	21	21	449	1,558
Petroleum - LPG	<1	<1	<1	<1	1	41	91
Petroleum - Lubricants	0	0	<1	<1	1	96	105
Petroleum - Motor Gasoline	0	<1	0	58	58	1,615	4,107
Petroleum - Residual Fuel Oil	0	0	<1	0	<1	<1	11
Petroleum - Special Naphthas	0	0	<1	0	<1	14	0
Petroleum - Petroleum coke	0	0	1	0	1	40	144
Petroleum - Waxes	0	0	<1	0	<1	0	0
Petroleum - Still gas	0	0	3	0	3	100	204
Petroleum - Unfinished oils	0	0	<1	0	<1	0	0
Petroleum - Misc. products	0	0	<1	0	<1	6	0
Hydropower	0	0	0	0	0	0	0
Biomass - Wood	<1	<1	1	0	2	0	0
Biomass - Waste	0	<1	<1	0	<1	2	0
Biomass - Fuel ethanol	0	<1	<1	4	4	<1	0
Wind	0	0	<1	0	<1	0	0
Geothermal	<1	<1	0	0	<1	0	0
Solar	<1	<1	0	0	<1	0	0
Electricity Retail	18	23	11	<1	52	1,532	7,733
Total End-Use Energy	**58**	**54**	**54**	**110**	**277**	**5,472**	**21,720**
Electric System Losses	40	48	23	<1	111		
Total Primary Energy	**98**	**102**	**77**	**110**	**388**		

TABLE 11: END-USE CONSUMPTION TABLE (2013)

Energy Type	Estimated County End-Use Energy Consumption					Energy Expenditure	GHGs from Energy Use
	Trillion Btu					Million $	1000 MTCO2e
	Res	Com	Ind	Trans	All Sectors	All Sectors	All Sectors
Coal	0	<1	9	0	9	65	864
Natural Gas	36	25	18	1	79	578	4,211
Petroleum - Asphalt and road oil	0	0	2	0	2	25	0
Petroleum - Aviation Gasoline	0	0	<1	<1	<1	5	11
Petroleum - Crude oil	0	0	0	0	0	0	0
Petroleum - Distillate Fuel Oil	<1	2	2	23	28	758	2,047
Petroleum - Kerosene	<1	<1	<1	0	<1	<1	<1
Petroleum - Kerosene-type jet fuel	0	0	0	22	22	472	1,583
Petroleum - LPG	<1	<1	<1	<1	1	0	90
Petroleum - Lubricants	0	0	<1	<1	1	33	100
Petroleum - Motor Gasoline	0	<1	0	59	59	1,662	4,143
Petroleum - Residual Fuel Oil	0	0	<1	0	<1	3	15
Petroleum - Special Naphthas	0	0	<1	0	<1	23	0
Petroleum - Petroleum coke	0	0	2	0	2	4	182
Petroleum - Waxes	0	0	<1	0	<1	0	0
Petroleum - Still gas	0	0	3	0	3	88	192
Petroleum - Unfinished oils	0	0	<1	0	<1	0	0
Petroleum - Misc. products	0	0	<1	0	<1	6	0
Hydropower	0	0	0	0	0	0	0
Biomass - Wood	<1	<1	<1	0	2	0	0
Biomass - Waste	0	0	<1	0	<1	1	0
Biomass - Fuel ethanol	0	<1	<1	4	4	<1	0
Wind	0	0	<1	0	<1	0	0
Geothermal	<1	<1	0	0	<1	0	0
Solar	<1	<1	0	0	<1	0	0
Electricity Retail	18	23	11	<1	51	1,413	7,646
Total End-Use Energy	**54**	**51**	**50**	**110**	**266**	**5,136**	**21,085**
Electric System Losses	39	48	23	<1	112		
Total Primary Energy	**94**	**99**	**73**	**110**	**378**		

TABLE 12: END-USE CONSUMPTION TABLE (2012)

Energy Type	Estimated County End-Use Energy Consumption					Energy Expenditure	GHGs from Energy Use
	Trillion Btu					Million $	1000 MTCO2e
	Res	Com	Ind	Trans	All Sectors	All Sectors	All Sectors
Coal	0	<1	8	0	9	47	839
Natural Gas	29	21	17	<1	69	505	3,652
Petroleum - Asphalt and road oil	0	0	2	0	2	30	0
Petroleum - Aviation Gasoline	0	0	0	<1	<1	6	12
Petroleum - Crude oil	0	0	0	0	0	0	0
Petroleum - Distillate Fuel Oil	<1	2	2	22	27	719	1,976
Petroleum - Kerosene	<1	<1	<1	0	<1	<1	<1
Petroleum - Kerosene-type jet fuel	0	0	0	20	20	437	1,426
Petroleum - LPG	<1	<1	<1	<1	1	26	74
Petroleum - Lubricants	0	0	<1	<1	1	84	93
Petroleum - Motor Gasoline	0	<1	0	57	57	1,641	4,029
Petroleum - Residual Fuel Oil	0	0	<1	0	<1	<1	6
Petroleum - Special Naphthas	0	0	<1	0	<1	2	0
Petroleum - Petroleum coke	0	0	2	0	2	63	230
Petroleum - Waxes	0	0	<1	0	<1	0	0
Petroleum - Still gas	0	0	3	0	3	91	195
Petroleum - Unfinished oils	0	0	<1	0	<1	0	0
Petroleum - Misc. products	0	0	<1	0	<1	5	0
Hydropower	0	0	0	0	0	0	0
Biomass - Wood	<1	<1	1	0	2	0	0
Biomass - Waste	0	0	<1	0	<1	1	0
Biomass - Fuel ethanol	0	<1	<1	4	4	<1	0
Wind	0	0	<1	0	<1	0	0
Geothermal	<1	<1	0	0	<1	0	0
Solar	0	<1	0	0	<1	0	0
Electricity Retail	18	23	11	<1	52	1,398	7,594
Total End-Use Energy	**48**	**48**	**49**	**105**	**250**	**5,055**	**20,126**
Electric System Losses	39	49	24	<1	112		
Total Primary Energy	**87**	**96**	**73**	**105**	**362**		

TABLE 13: END-USE CONSUMPTION TABLE (2011)

Energy Type	Estimated County End-Use Energy Consumption					Energy Expenditure	GHGs from Energy Use
	Trillion Btu					Million $	1000 MTCO2e
	Res	Com	Ind	Trans	All Sectors	All Sectors	All Sectors
Coal	0	<1	7	0	8	37	741
Natural Gas	34	23	17	1	76	625	4,013
Petroleum - Asphalt and road oil	0	0	2	0	2	23	0
Petroleum - Aviation Gasoline	0	0	0	<1	<1	6	14
Petroleum - Crude oil	0	0	0	0	0	0	0
Petroleum - Distillate Fuel Oil	<1	2	2	24	28	714	2,045
Petroleum - Kerosene	<1	<1	<1	0	<1	<1	2
Petroleum - Kerosene-type jet fuel	0	0	0	21	21	450	1,520
Petroleum - LPG	<1	<1	<1	<1	1	32	86
Petroleum - Lubricants	0	0	<1	<1	1	85	101
Petroleum - Motor Gasoline	0	<1	0	57	57	1,565	4,045
Petroleum - Residual Fuel Oil	0	0	<1	0	<1	<1	14
Petroleum - Special Naphthas	0	0	<1	0	<1	2	0
Petroleum - Petroleum coke	0	0	2	0	2	56	221
Petroleum - Waxes	0	0	<1	0	<1	0	0
Petroleum - Still gas	0	0	3	0	3	85	190
Petroleum - Unfinished oils	0	0	<1	0	<1	0	0
Petroleum - Misc. products	0	0	<1	0	<1	5	0
Hydropower	0	0	0	0	0	0	0
Biomass - Wood	<1	<1	1	0	2	0	0
Biomass - Waste	0	0	<1	0	<1	1	0
Biomass - Fuel ethanol	0	<1	<1	4	4	<1	0
Wind	0	0	<1	0	<1	0	0
Geothermal	<1	<1	0	0	<1	0	0
Solar	0	<1	0	0	<1	0	0
Electricity Retail	19	22	11	<1	52	1,368	7,981
Total End-Use Energy	**53**	**49**	**48**	**108**	**258**	**5,055**	**20,973**
Electric System Losses	42	50	25	<1	117		
Total Primary Energy	**95**	**99**	**73**	**108**	**375**		

TABLE 14: END-USE CONSUMPTION TABLE (2010)

Energy Type	Estimated County End-Use Energy Consumption					Energy Expenditure	GHGs from Energy Use
	Trillion Btu					Million $	1000 MTCO2e
	Res	Com	Ind	Trans	All Sectors	All Sectors	All Sectors
Coal	0	<1	7	0	8	35	787
Natural Gas	34	23	18	1	75	630	4,003
Petroleum - Asphalt and road oil	0	0	2	0	2	23	0
Petroleum - Aviation Gasoline	0	0	<1	<1	<1	5	14
Petroleum - Crude oil	0	0	0	0	0	0	0
Petroleum - Distillate Fuel Oil	<1	2	2	24	28	545	2,084
Petroleum - Kerosene	<1	<1	<1	0	<1	1	5
Petroleum - Kerosene-type jet fuel	0	0	0	21	21	315	1,520
Petroleum - LPG	<1	<1	<1	<1	1	26	81
Petroleum - Lubricants	0	0	<1	<1	1	72	105
Petroleum - Motor Gasoline	0	<1	0	57	58	1,197	4,054
Petroleum - Residual Fuel Oil	0	0	<1	0	<1	<1	19
Petroleum - Special Naphthas	0	0	<1	0	<1	2	0
Petroleum - Petroleum coke	0	0	2	0	2	45	233
Petroleum - Waxes	0	0	<1	0	<1	0	0
Petroleum - Still gas	0	0	3	0	3	78	191
Petroleum - Unfinished oils	0	0	<1	0	<1	0	0
Petroleum - Misc. products	0	0	<1	0	<1	3	0
Hydropower	0	0	0	0	0	0	0
Biomass - Wood	<1	<1	1	0	2	0	0
Biomass - Waste	0	0	<1	0	<1	<1	0
Biomass - Fuel ethanol	0	<1	<1	4	4	<1	0
Wind	0	0	0	0	0	0	0
Geothermal	<1	<1	0	0	<1	0	0
Solar	0	<1	0	0	<1	0	0
Electricity Retail	19	22	11	<1	53	1,341	8,152
Total End-Use Energy	**54**	**49**	**49**	**108**	**260**	**4,319**	**21,249**
Electric System Losses	43	50	26	<1	119		
Total Primary Energy	**97**	**99**	**75**	**108**	**379**		


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