Floyd County 2009 Community Energy and Emissions Summary

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BACKGROUND

The report summarizes a baseline analysis and inventory of the energy usage, carbon emissions, and criteria air pollutants for Floyd, County, VA, for 2009. Such analysis are increasingly common for communities as planning tools as energy prices rise and environmental regulations become more stringent. Like a budget, such an analysis is useful as a baseline by which to compare options and progress in future years. Without a baseline analysis, it is very difficult to prioritize the most feasible and cost effective options for reducing energy use and associated environmental emissions.

Energy is a critical issue for the future as energy demands increase both domestically and globally. At the same time, non-renewable fossil fuel resources like oil, coal, and natural gas which provide the majority of the world's energy are continually being depleted. Moreover, while new potential energy sources like natural gas from shale and oil from tar sands may seem like promising candidates to increase supply, these are still fossil fuels and the environmental impacts due to extraction and processing come with additional environmental impacts.

Carbon dioxide (CO_2) is a colorless, odorless gas which plays a critical role in the carbon cycle necessary for life on earth. This gas is the by-product of human and animal respiration and this gas is also absorbed by plants for use in photosynthesis. The concentration of carbon dioxide in the atmosphere is approximately 390 parts per million (ppm) and increasing due to the use of fossil fuels. The combustion of fossil fuels releases the inherent chemical energy to provide energy for electricity, heating, and transportation. The carbon in the fossil fuels is oxidized during combustion with oxygen and the by-products are primarily carbon dioxide and water. This carbon dioxide has a long lifetime in the atmosphere, several decades to a century, which makes this a long term problem.

While carbon dioxide is a natural part of the earth's cycles, there are impacts due to increasing concentrations of this chemical in the atmosphere. Carbon dioxide and other greenhouse gases (GHGs) have a chemical structure that allows them to absorb certain wavelength of radiant energy. In the atmosphere, these GHGs lead to warming which, in turn, warms the earth below. Models predict that without our atmosphere containing GHGs, the earth would be much colder; in fact, there would be no liquid water, and life as we know it would not exist.

So, while carbon dioxide and GHGs are critical to life on this planet, a fine balance is required. While the concentration of CO_2 in the atmosphere is quite small in an absolute sense, increases due to fossil fuel use leads to an imbalance in the carbon cycle. More CO_2 in the atmosphere leads to increased atmospheric and planetary temperatures - this process is commonly known as global warming. Global warming models attempt to predict the effect of this and other changes to the atmosphere, oceans, and land. While weather patterns, solar variations, volcanoes, forest fires, and other natural processes around the globe do change the global average temperature and can lead to warming, none of the models can accurately predict the changes seen in the past without including the role of carbon dioxide warming in the atmosphere.

Even though global climate and temperature scientific models continue to be improved, like weather predictions they are not fully understood due to the complexity of the earth systems. This uncertainty leads some people to question everything about global warming. However, there is little scientific uncertainty regarding the increasing concentration of carbon dioxide in the atmosphere or the rising global and ocean average temperatures. While a few degrees of global warming may not seem like a significant change, this is expected to have major impacts to the world's climate and ecosystems. The questions that are still debatable are not whether our use of fossil fuels contributes to global warming, but rather how much warming will result from increasing CO_2 levels, how fast will this warming occur, and how severe will be the potential consequences like sea level rise, ecosystem damage, changes in food production, and the spread of disease. While these consequences continue to be studied by scientists, it is prudent to consider options to reduce these potentially irreversible environmental impacts.

While much attention is given to the carbon dioxide emissions from fossil fuels, it is also important to consider the other pollutants that are emitted. Criteria air pollutants (CAPs) are chemicals in the atmosphere are limited by the federal National Ambient Air Quality Standards which are set by the EPA as required by the Clean Air Act. There are 6 common CAPs and they are limited since there is strong evidence that they damage human health and the environment today. The CAPs are particulate matter (PM), ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. The pollutants have immediate health and environmental effects which provide even more reason to address their sources which again are due to fossil fuel use.

Particulate matter is like soot, that is, very small particles created in the combustion of fuels. These particles, often 10 microns in size and smaller, can get deep into the lungs when inhaled leading to serious health problems. PM has been linked to a variety of lung and heart problems, including decreased lung function, aggravated asthma, development of chronic bronchitis, heart attacks and premature death in people with heart or lung disease.

Ozone is not emitted directly into the air, but at ground-level is created by a chemical reaction between nitrogen oxides and volatile organic compounds (VOCs) in the presence of sunlight. Ozone is the primary component of what we generally call smog. Exhaust from vehicles, industrial emissions, gasoline vapors, and other chemical solvents lead to the formation of ozone especially on hot summer days. Ozone also leads to health problems associated with the lungs and heart. It is important to differentiate between this ground-level ozone which is harmful and the upper atmospheric ozone which is beneficial since it blocks UV light from the sun which can cause skin cancer, cataracts, and other environmental problems. Ozone in the upper atmosphere has been depleted in recent decades by chlorofluorocarbons (CFCs), a class of chemicals used in aerosol cans and as refrigerants.

Nitrogen and sulfur oxides are CAPs which also cause respiratory problems. Nitrogen oxides results mainly from vehicle exhaust emissions whereas sulfur oxides are more likely to come from the coal combusted by power plants or other large industries, though some results from high sulfur fuels.

Lead is less common in the air in recent years due to rules which have limited lead in fuels. The major sources of lead emissions to the air today are ore and metals processing and some aircraft which still operate using leaded aviation fuel. Lead causes neurological effects in children and cardiovascular effects in adults. Mercury causes similar neurological effects to lead, and is not a CAP, but is emitted into the atmosphere primarily by the combustion of coal. This mercury eventually deposits on land or in water and is its form changes to methylmercury, a toxic chemical the bioaccumulates in fish, shellfish, and animals the eat fish. As reported commonly in the news, and signs in some local rivers, human exposure to mercury is mainly through the consumption of fish and shellfish.

For all of these pollutants, the effects are typically worse for the elderly, children, and others with compromised immune systems. In addition to the human loss of life or quality of life which can be attributed to CAPs, there is a large societal cost both in terms of health care expenses and reduced productivity due to lost work days. Furthermore, cities with pollution levels above the CAP limits can have economic growth ramifications in terms of some new businesses getting permits for operation.

Fortunately, reductions in energy use typically lead to the triple reduction in carbon dioxide emissions, emissions of criteria air pollutants, and energy expenditures. This baseline analysis will identify the major sources of energy and emissions and provide data for informed decisions regarding options for future reductions.

METHODOLOGY

This analysis uses published emission coefficients for carbon dioxide and methane as the primary greenhouse gases. As is standard practice, carbon dioxide is considered the reference chemical and the global warming potential for other chemicals like methane is used to convert all emissions to carbon dioxide equivalents ($CO_{2,\ equiv}$).

Emissions coefficients were also used for a less detailed analysis of mercury and the EPA Criteria Air Pollutants. The models for these pollutants and the associated emissions coefficients are more difficult to apply and confirm compared to the greenhouse gas models which are well established.

SCOPE AND ASSUMPTIONS

The following are scope boundaries and assumptions were used for the analysis reported in this document:

- The baseline calendar year is chosen as 2009.
- The county limits were used as physical boundaries, with details given below in the data section for each category
- Wood use for home heating was considered carbon neutral from an emission perspective. In other word, the carbon dioxide released during combustion of the wood was considered equal to the carbon dioxide sequestered by the tree as it grew prior to harvesting. While this is not strictly true since energy and associated emissions also results from processing and transportation of wood, it is a reasonable assumption for the level of detail required in this analysis. This analysis does not estimate particulate emissions from wood, but this is an issue since wood burning stoves often generate relatively high amounts of particulate matter.
- Carbon emissions credits, but not criteria air pollutant credits, are calculated for the recycling of paper, plastic, metal and glass. However, they are not included in the summary emissions totals but rather discussed in more detail in the recycling section.

- The following were <u>not</u> included in the analysis, but do contribute to emissions. It is assumed the contributions in these categories are relatively small compared to the overall community values. Future analyses could add detail in these or other categories.

    - On-farm fuel usage since VDOT data is collected from road estimates while farm fuel data is not typically compiled in any one location
    - Direct carbon emissions from waste water treatment (indirect emissions from energy use associated with water treatment are included)
    - Emissions due to airline travel. To include this, one has to decide on the complex issue of allocating these emissions since flights necessarily go to destinations outside Floyd.
    - All indirect emissions results from materials and processes to produce consumer items and food for Floyd county citizens.

COMMUNITY BASELINE DATA

Electricity

Electricity data was provided by Appalachian Power Company (APCO), a division of American Electric Power (AEP). The boundaries for this data included Floyd County for the calendar year 2009 as defined by APCO using their “tax district” reporting field which indicates where accounts are located for the purpose of collecting and paying taxes that localities charge their customers. Therefore, the electricity values correspond to billed usage and can be further broken down into sectors since electrical rates vary depending on end use. The electricity data was divided into subcategories as shown in table 1 and figure 1. Note that electricity use for Floyd County is dominated by the residential sector at 70%. The “Other” category for electricity usage corresponds to schools, local/state/federal governments, public authorities, etc.

Sector	Kilowatt Hours (kWh)	Data Source
Residential	90,468,966	Bill Rogers
Commercial	19,661,079	Appalachian Power Co.
Industrial	12,967,481	
Other	6,485,234	
Totals	129,582,760	

Table 1 – Floyd County electrical usage 2009

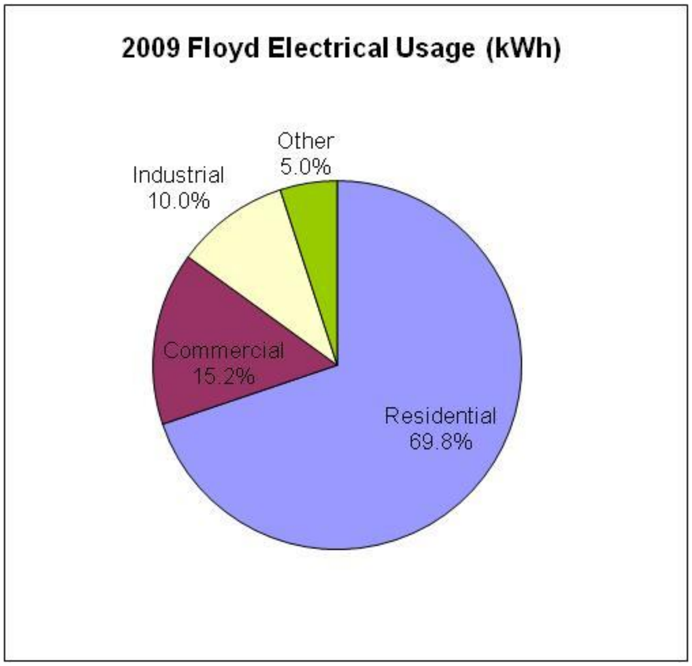


Figure 1 – Floyd County electrical usage breakdown

Emissions due to community electricity usage come from the utility power plants which are not located in the community. Greenhouse gas emissions from such sources are more of a global concern, while criteria air pollutants have more local and regional effects. Accurate emission estimates due to electricity require the proper emission coefficients which detail the individual emission amounts based on a per kWh basis and vary significantly depending on the specific fuel mix used to generate the electricity. For example, electricity generated by coal has more carbon dioxide emissions per kWh than that generated based on natural gas which in turn emits significantly more carbon dioxide than hydropower or nuclear generated electricity. Note that these emissions coefficients typically only consider the emissions released in the generation and transmission phases of the electrical generation life cycle which means they do not include any emissions related to extraction of fuels, processing of fuels, transportation of fuels, capital equipment, or waste disposal. Based on APCO published regulatory data[10], the emissions factors used in this analysis are detailed in table 2.

Emission Chemical(s)	2009 APCO Data (lbs/kWh)
CO_2 (lbs/kWh)	1.825
SO_2 (lbs/kWh)	0.0065
NO_x (lbs/kWh)	0.0013

Table 2 – Electrical power generation emission coefficients

Heating Oil and Propane

There is no utility-provided natural gas used in Floyd County so this energy source was considered negligible in this analysis. Heating oil and propane, however, provide a significant amount of heating in the community and usage data were provided by the suppliers shown in table 3 below. Individual amounts of oil and propane supplied to the community are considered proprietary, but the data has been aggregated in table 3.

	HEATING OIL SALES (gallons)		PROPANE SALES (gallons)	
SUPPLIER	**Residential**	**Commercial**	**Residential**	**Commercial**
Blue Ridge Propane				
Conny Oil				
Southwestern Va Gas Service				
APB Whiting Oil Co.				
Clark Gas & Oil Co., Inc.				
Amerigas				
Midway Oil				
Hutchens Petroleum				
Total	619,439	430,676	525,930	607,820

Table 3 – Floyd County heating oil and propane suppliers and usage (2009)

Transportation Fuel

Emissions from transportation fuels are estimated from fuel usage data. Actual fuel purchases are not available since the fuel is purchased by a large number of community customers from a variety of sources. Without actual fuel usage data, various methods can be used to estimate emissions, each with advantages and disadvantages. This analysis used Vehicle Miles Traveled (VMT) data provided by the Virginia Department of Transportation (VDOT) for Floyd County and the Town of Floyd. This data is compiled in Table 4. Daily Vehicle Miles Traveled (DVMT) is converted to Annual Vehicle Miles Traveled (AVMT) simply by multiplying by 365 days/year. The AVMT for Floyd County in 2009 using this methodology was 129,163,560 miles.

VMT data is obtained by VDOT from traffic surveys and other estimates of actual miles driven. This data is independent of the where the vehicle is registered so it accounts for traffic on Floyd roads by people from outside the community. VMT data is split into primary and secondary roads with approximately 60% of VMT in Floyd on primary roads and 40% on secondary roads.

Emissions depend on fuel usage, not VMT, so the latter is converted to the former with estimates of vehicle fuel efficiency. Emissions from transportation fuel combustion depend upon the amount of fuel used, the type of fuel, and the characteristics of the engine which is combusting the fuel. The fuel economy estimates for different vehicle classes are listed in the MPG column of Table 4 and can be broken down into more detail in subsequent analyses if more accuracy is desired. For this baseline analysis, these estimates are considered reasonable. The carbon emissions are estimated using the CO_2 coefficient column in Table 4. The carbon dioxide emissions values from the US Energy Information Administration (EIA) are 20 lbs CO_2/gallon for gasoline and 22 lbs CO_2/gallon for diesel fuel.[1] The total estimated carbon dioxide emissions from transportation fuels is approximately 69,000 tons with 70% of this coming from the category of passenger cars.

Analysis of Floyd County Fleet data including fire, administration, police, rescue, etc indicate that the carbon dioxide emissions from this subset of transportation is 537 tons, a small percentage of the total transportation emissions. Details are provided in the appendix.

Vehicle Category	Secondary Roads DVMT	Primary Road DVMT	Total DVMT	AVMT	MPG	Gallons	CO_2 Coefficient (lbs/gallon)	ESTIMATED CO_2 Emissions (tons)
Motorcycles	662	819	1,481	540,498	30	18,017	20	180
Passenger Cars	111,697	156,455	268,152	97,875,327	22	4,448,878	20	44,489
Two Axle, 4 Tire Single Unit Vehicles	19,011	42,318	61,329	22,384,920	15	1,492,328	20	14,923
Busses	287	1,760	2,047	747,058	6	124,510	22	1,370
Two Axle, 6 Tire Single Unit Trucks	763	1,970	2,732	997,240	6	166,207	22	1,828
Three Axle Single Unit Trucks	886	1,268	2,154	786,126	6	131,021	22	1,441
Four or More Axle Single Unit Trucks	163	304	467	170,313	6	28,386	22	312
Four Axle or Fewer Single Trailers	199	651	850	310,312	6	51,719	22	569
Five Axle Single Trailers	249	2,008	2,256	823,583	6	137,264	22	1,510
Six or More Axle Single Trailers	15	44	60	21,786	6	3,631	22	40
Five Axle or Fewer Multi-Trailers	0	2	2	633	6	106	22	1
Six Axle Multi-Trailers	0	0	0	0	6	0	22	0
Seven or More Axle Multi-Trailers	0	0	0	0	6	0	22	0
Floyd County Totals	**133,931**	**207,597**	**341,528**	124,657,798		6,602,065		-
Motorcycles	4	29	33	12,103	30	403	20	4
Passenger Cars	3,386	6,304	9,690	3,536,899	22	160,768	20	1,608
Two Axle, 4 Tire Single Unit Vehicles	105	2,101	2,206	805,289	15	53,686	20	537
Busses	1	96	97	35,577	6	5,929	22	65
Two Axle, 6 Tire Single Unit Trucks	2	107	109	39,890	6	6,648	22	73
Three Axle Single Unit Trucks	3	68	71	26,062	6	4,344	22	48
Four or More Axle Single Unit Trucks	0	17	17	6,191	6	1,032	22	11
Four Axle or Fewer Single Trailers	1	31	32	11,731	6	1,955	22	22
Five Axle Single Trailers	1	86	87	31,608	6	5,268	22	58
Six or More Axle Single Trailers	0	1	1	383	6	64	22	1
Five Axle or Fewer Multi-Trailers	0	0	0	29	6	5	22	0
Town of Floyd Totals	**3,504**	**8,841**	**12,345**	4,505,762		240,103		
TOTALS	137,435	216,438	353,873	129,163,560		6,842,168		***69,090***

Table 4 – Floyd County VDOT data (2009)

Waste Disposal

Waste disposal contributes to emissions mainly through landfills which emit methane, a potent greenhouse gas, as a result of the anaerobic decomposition of organic matter. In some landfill analyses, managed landfills are also given credit for CO_2 sequestration which reduces the equivalent CO_2 emissions from the landfill. The argument for this assumption is that some of the carbon stored in a managed landfill will not be emitted - in contrast to incinerated waste, for example, where carbon dioxide is emitted due to the combustion process. In this analysis, carbon sequestration is <u>not</u> considered.

There are several methods for estimating the greenhouse gas emissions due to landfill wastes. The *Methane Commitment Method* assigns all <u>total lifetime</u> greenhouse gas emissions from the waste disposed in the active year to <u>that</u> year. In reality, methane emissions occur over time from a landfill, but estimating this dynamic process accurately using a *Waste-in-Place Method* requires waste data, landfill inception dates, and closing dates for all landfills within the analysis boundaries. This report uses both the *Methane Commitment Method* which assigns all of the methane emissions that will occur over the lifetime of the landfill in which the 2009 wastes were stored to the greenhouse gas inventory for this year <u>and</u> the *Waste-in-Place Method* to account for emissions in 2009 due to waste in previously closed landfills.

Methane has a global warming potential 21 times that of carbon dioxide over 100 years according to the International Panel on Climate Change (IPCC).[2] Therefore, all methane landfill emission amounts in this analysis are multiplied by 21 to get a carbon dioxide equivalent emissions. If another time scale is used, this global warming potential will change, but methane is still more potent than carbon dioxide for atmospheric warming.

For the Floyd County landfill, opened in 1973 and closed in 1994, the EPA Landgem model was used to estimate landfill emissions for 2009.[3] The model parameters in table 5 were used according to the EPA Greenhouse Gas Reporting Rule Parameters.

Model Parameter	Value
Methane Generation Rate, k	*0.057/year*
Potential Methane Generation Capacity, L_o	*100 m^3/Mg*
NMOC Concentration	*600 ppmv as hexane*
Methane Content	*50% by volume*

Table 5 – Landfill emission model parameters for closed Floyd County landfill

Both methane and carbon dioxide emissions are provided by the Landgem model. Details are shown in the tables in the appendix. The carbon dioxide equivalent emissions are 354 tons for carbon dioxide emissions and 7,438 tons for methane emissions.

Floyd County transfers current solid wastes to the New River Resource Authority's Cloyd's Mountain Landfill. For these land fill emissions, the analysis uses the Methane Commitment method which considers all emissions due to the 2009 landfilled waste as 2009 emissions. To estimate lifetime methane emissions for 2009 solid waste, the Potential Methane Generation Capacity, L_o, was 0.067 tons methane/ton solid waste (this is approximately equivalent to the table above parameters with L_o equal to 100 m^3/Mg and a density of 0.67 kg/m^3 for methane).[4] Using this value the methane emissions for 2009 solid waste are 755 tons corresponding to carbon dioxide equivalent emissions of 15,855 tons.

Recycling

Recycling is not included as a source of carbon emissions **reduction** in this analysis, even though significant upstream emissions from manufacturing energy are reduced due to this practice. This is due to the fact that recycling is necessarily due to the consumption of more materials. The emissions from the consumption of products is not included in this analysis which focused on direct emissions due to use of electricity and fuels, therefore it is not consistent to give reduction credits in this way. As an example, recycling amounts could increase due only to the consumption of more products and not necessarily due to increased recycling percentages. However, recycling emissions reductions are quantified in this section since it is an important factor in the broad plans for reduced emissions.

Table 6 shows the tons of recycling in Floyd County in 2009 in a variety of material categories. The EPA Waste Reduction Model (WARM) is used to estimate the carbon dioxide that is not emitted relative to the case where the materials are landfilled.[5] The WARM landfill coefficients are subtracted from the recycling emissions coefficients since there are some emissions just associated with landfilling these materials. For a few of the less commonly recycled materials in Table 6, no coefficients were found so these were omitted from the analysis. For recycled waste wood, it was assumed that the material would otherwise go to the landfill where it would degrade into methane so the EPA landfill model from CFR Part 98 HH was used with a degradable organic carbon (DOC) factor of 0.43 for wood.[4] It was also assumed that the used oil in Table 6 was recycled by burning this oil for heat energy which is a common practice but does release carbon dioxide in the combustion process. The factor used to estimate these emissions was that for burning of diesel fuel. The overall carbon dioxide reduction due to recycling in this analysis was 8,942 tons.

		EPA WARM Emissions (metric tons CO_2 equivalent/short ton)					
Category	**Tons**	**Recycling**	**Landfilling, National Average**	**Total**	**WARM notes**	**Other Emissions Coefficients**	**Carbon Emissions (tons)**
Paper	349	-3.51	0.05	-3.56	Mixed Paper (general)		(1,127)
Metal*	976	-5.4	0.04	-5.44	Mixed Metals		(4,818)
Plastic	52	-1.5	0.04	-1.54	Mixed Plastics		(73)
Glass	25	-0.28	0.04	-0.32			(7)
Waste wood	1,056					-0.143	(3171)
Tires	134	-0.39	0.04	-0.43			(52)
Used Oil	104					22	306
Used Antifreeze	3.3						
Batteries	56						
Electronics	4.0						
Total Recycling	2,760						(8,942)

Table 6 – Floyd County Recycling Data (2009)

Carbon Emissions

Combining the emissions analysis data, the estimated total carbon emissions for Floyd County in this 2009 baseline analysis are 230,136 tons. For reference to the scale of these emissions, I ton of carbon dioxide at standard temperature and pressure fills a cube which sides of 26 feet. The breakdown of these emissions is detailed in Table 7 and Figure 2. Electricity usage and transportation fuels dominate the emissions. The carbon dioxide emissions savings due to recycling in Floyd was not included in this summary, as detailed in the section above, but was approximately 4% of the total emissions.

It is tempting to want to compare carbon emissions from Floyd County to other cities and counties. However, this is difficult and often misleading since good comparisons require analyses with similar scope and assumptions. Moreover, cities and counties have different industrial, transportation, land use, housing, and energy use characteristics which make comparisons unfair. However, for reference purposes, it is reasonable to look at average US carbon dioxide emissions. According to the US Census Bureau, the population of Floyd County was approximately 15,000 in 2009. Based on this analysis, this gives a per capita emission value of 15 tons carbon dioxide/person. The US carbon dioxide emissions in 2009 were approximately 5500 million metric tons (MMT) of carbon dioxide equivalent[6] and the population was approximately 305 million. This data give a US average per capita carbon emission of 19.9, which is not unexpected given the rural nature of Floyd County.

Source	$CO_{2, equiv}$ (tons)	Percentage
Electricity	118,568	51.5%
Transportation	68,959	30.0%
Solid Waste	15,855	6.9%
Heating Oil	11,761	5.1%
Floyd County Landfill	7,792	3.4%
Propane	7,199	3.1%
Total	***230,136***	***100%***

Table 7 – Floyd County Carbon Dioxide Equivalent Emissions (2009)

It is tempting to want to compare carbon emissions from Floyd County to other cities and counties. However, this is difficult and often misleading since good comparisons require analyses with similar scope and assumptions. Moreover, cities and counties have different industrial, transportation, land use, housing, and energy use characteristics which make comparisons unfair. However, for reference purposes, it is reasonable to look at average US carbon dioxide emissions. According to the US Census Bureau, the population of Floyd County was approximately 15,000 in 2009. Based on this analysis, this gives a per capita emission value of 15 tons carbon dioxide/person. The US carbon dioxide emissions in 2009 were approximately 5500 million metric tons (MMT) of carbon dioxide equivalent[6] and the population was approximately 305 million. This data give a US average per capita carbon emission of 19.9, which is not unexpected given the rural nature of Floyd County.

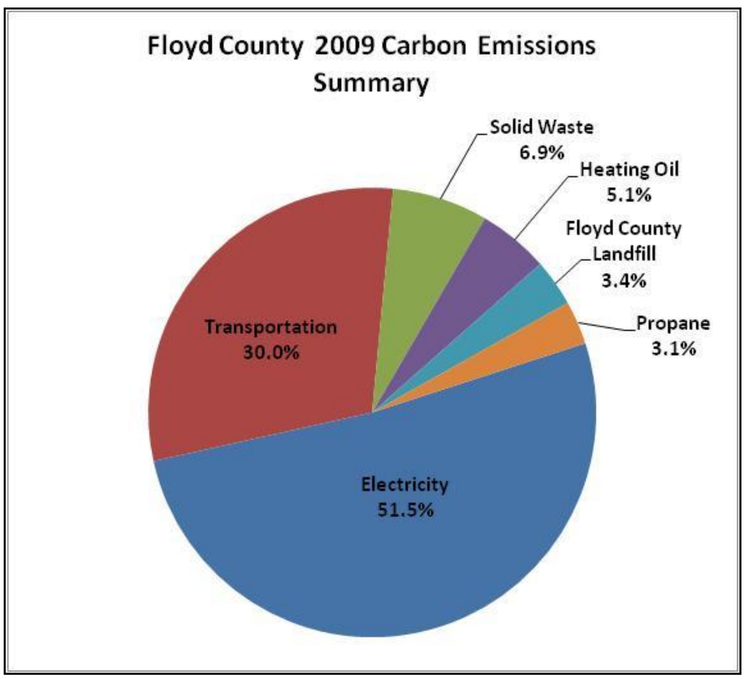


Figure 2 – Floyd County Carbon Emissions (2009)

Criteria Air Pollutants

Estimates of criteria air pollutants (CAPs) for vehicles and other fuel usage are based on complex models and emissions coefficients. A detailed analysis is out of the scope of this report, but a brief analysis is provided below to highlight that the use of energy leads to more potential environmental and health issues than just greenhouse gases.

Table 8 from the GREET Transportation Fuel Cycle model developed by Argonne National Lab provides emissions factors for cars using reformulated gasoline.[7] Note that these are life cycle emissions which account not only for vehicle use, but also for primary fuel recovery, preparation, and delivery. These latter life cycle emissions are not included in the primary carbon dioxide emissions analysis of this report. Since 70% of the vehicle miles travelled in Floyd were associated with gasoline vehicles, these emissions factors were also applied to the total AVMT of 129,163,560 miles as an estimate even though the emissions for diesel vehicles will be different.

Criteria Air Pollutant	Gasoline Car Emissions (grams/mile)	Total Estimated Emissions (tons)
Carbon Monoxide (CO)	2.906	413
Volatile Organic Compounds (VOC)	0.209	29.7
Oxides of Nitrogen (NO_x)	0.212	30.2
Particulate Matter (PM_{10})	0.047	6.7
Sulfur Oxides (SO_x)	0.085	12.1

Table 8 – Life Cycle CAP Emission Estimates for Floyd transportation

Table 9 shows a summary of electricity emissions factors for Virginia compiled from several sources as noted. The values for NO_x and SO_2 values come from Appalachian Power 2009 information in Table 2. The mercury (Hg) value is compiled from the EPA EGrid2007 for 2005 year data.[8]

More detailed emissions factors for Appalachian Power were not found. The other emissions factors for Appalachian Power may differ from the Virginia average, but this is the best referenced data that was found and serves as a reasonable estimate for pollutant emissions due to electricity use given the lack of more specific data. In table 10, these factors were multiplied by the overall electricity use in Floyd County (129,582,760 kWh) to obtain total emissions.

State	NO_x (lbs/kWh)[9]	SO_2 (lbs/kWh)[9]	Hg (lbs/kWh)[7]	PM10
Virginia	0.0013	0.0065	1.684E-08	Not available

Table 9 –Emissions Factors for Electricity (2005)

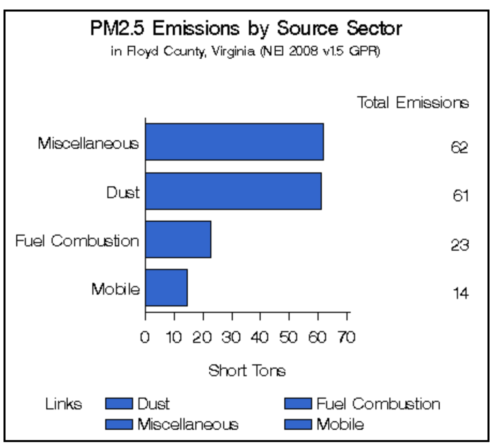
NO_x (lbs)	SO_2 (lbs)	Hg (lbs)	PM10
168,500	842,300	2.2	???

Table 10 –Selected CAP Emissions due to Electricity Usage

Data for mercury emissions for Appalachian Power in SW Virginia were not found so this average value was used to get an estimate understanding that it may be significantly different depending on the fuel source and generation technology. This gives a mercury emission of 2.2 lbs due to electricity generation in 2009 for Floyd County.

Mercury emissions from gasoline and diesel have been studied by the EPA, but the values are on the order of 1 and 10 nanogram/mile, respectively, which is insignificant compared to the emissions from electricity usage.[9]

Particulate matter is also difficult to measure and attribute to specific sources. No data was found detailing the typical PM emissions per kWh of electricity generated. However, an idea of the PM source contributions can be found in the EPA Air Emissions Summary data shown in Table 11.[11] This data indicates higher PM emissions from vehicles in Floyd, listed as "Mobile" sources in the graph below, compared to the state. The emissions below are also higher than the number calculated above but in the same order of magnitude. "Fuel Combustion" in the graph below refers to propane, oil, and wood combustion, but the PM emissions due to Floyd County energy use are actually much higher due to electricity generation; these emissions occur in the location of the power plants supplying the electricity and show up in the state data. As a rural county, more of the emissions are due to "Dust" and "Miscellaneous" which is emissions that cannot be attributed a specific source.



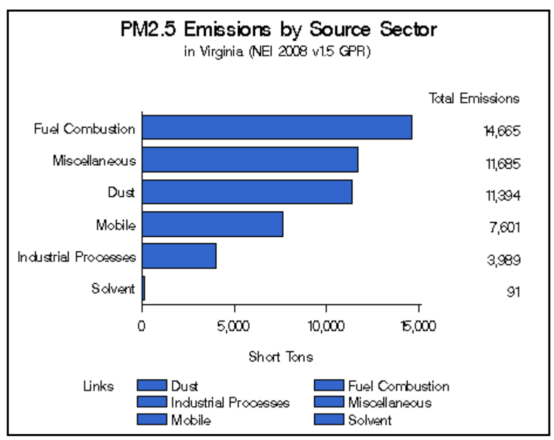


Table 11 –PM Emissions by Source in Floyd County and Virginia[11]

CONCLUSIONS

The carbon dioxide emissions based on the use of community wide energy in Floyd County and the Town of Floyd including electricity, on-road vehicles, heating oil, propane, and landfill waste is approximately 230,000 tons of carbon dioxide equivalent. Slightly more than 50% of the carbon emissions results from electricity while 30% of the emissions come from gasoline and diesel vehicles. Therefore, initiatives to reduce energy use and carbon dioxide emissions should be focused in these areas. Criteria air pollutant emissions are much smaller in magnitude than the greenhouse gas emissions, but still have a negative environmental effect and should be considered in plans for environmental initiatives.

REFERENCES

[1]http://www.eia.gov/oiaf/1605/coefficients.html
[2]http://www.epa.gov/outreach/scientific.html
[3]United States Environmental Protection Agency (EPA), Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide, EPA-600/R-05/047, May 2005.
[4]Federal Register, Vol. 74, No. 209, October 30, 2009, Rules and Regulations, CFR Part 98 – Mandatory Greenhouse Gas Reporting, Table HH–1 to Subpart HH of Part 98—Emissions Factors, Oxidation Factors, and Methods, pp. 56479.
[5]EPA Waste Reduction Model (WARM), Version 11, August 2010, *http://epa.gov/climatechange/wycd/waste/calculators/Warm_home.html#click*
[6]*Inventory of US Green house Gas Emissions and Sinks: 1990 - 2009*, April 2011, USEPA #430-R-11-00, http://epa.gov/climatechange/emissions/usinventoryreport.html
[7]http://www.afdc.energy.gov/afdc/vehicles/emissions_electricity.html
[8] *Leonardo Academy's Guide to Calculating Emissions Including Emission Factors and Energy Prices*, Leonardo Academy Inc., Updated May 27, 2010, *www.leonardoacademy.org*
[9]M. Hoyer, R. Baldauf, C. Scarbro, J. Barres, and G. Keeler, *Mercury Emissions from Motor Vehicles*, 13th International Inventory Conference, 2004.
[10]Appalachian Power Company, 2009 Environmental Information insert.
[11]Environmental Protection Agency, *http://www.epa.gov* → Air & Radiation → Air Emission Sources → State and County Emission Summaries

APPENDIX

1 0714 - Closed Floyd County Landfill- LandGEM Model Run

RESULTS

Landfill Name or Identifier: Floyd County Landfill - Using GHG-RR Parameters

Total landfill gas in cubic ft. per min.

Methane in cubic ft per min

Closure Year (with 80-year limit) = 1994

Methane = 50 % *by volume*

Please choose a third unit of measure to represent all of the emission rates below.

User-specified Unit: av ft^3/min

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide		
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*	*(Mg/year)*	*(m³/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m³/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m³/year)*	*(av ft^3/min)*
1973	5,925	6,518	0	0	0	0	0	0	0	0	0	0	0
1974	5,925	6,518	5,925	6,518	8.260E+01	6.614E+04	4.444E+00	2.206E+01	3.307E+04	2.222E+00	6.053E+01	3.307E+04	2.222E+00
1975	5,925	6,518	11,850	13,035	1.606E+02	1.286E+05	8.642E+00	4.290E+01	6.431E+04	4.321E+00	1.177E+02	6.431E+04	4.321E+00
1976	5,925	6,518	17,775	19,553	2.343E+02	1.876E+05	1.261E+01	6.259E+01	9.381E+04	6.303E+00	1.717E+02	9.381E+04	6.303E+00
1977	5,925	6,518	23,700	26,070	3.039E+02	2.434E+05	1.635E+01	8.118E+01	1.217E+05	8.176E+00	2.227E+02	1.217E+05	8.176E+00
1978	5,925	6,518	29,625	32,588	3.697E+02	2.960E+05	1.989E+01	9.875E+01	1.480E+05	9.945E+00	2.709E+02	1.480E+05	9.945E+00
1979	5,925	6,518	35,550	39,105	4.318E+02	3.458E+05	2.323E+01	1.153E+02	1.729E+05	1.162E+01	3.165E+02	1.729E+05	1.162E+01
1980	5,925	6,518	41,475	45,623	4.905E+02	3.927E+05	2.639E+01	1.310E+02	1.964E+05	1.319E+01	3.595E+02	1.964E+05	1.319E+01
1981	5,925	6,518	47,400	52,140	5.459E+02	4.371E+05	2.937E+01	1.458E+02	2.186E+05	1.469E+01	4.001E+02	2.186E+05	1.469E+01
1982	5,925	6,518	53,325	58,658	5.982E+02	4.790E+05	3.219E+01	1.598E+02	2.395E+05	1.609E+01	4.384E+02	2.395E+05	1.609E+01
1983	5,925	6,518	59,250	65,175	6.477E+02	5.186E+05	3.486E+01	1.730E+02	2.593E+05	1.742E+01	4.747E+02	2.593E+05	1.742E+01
1984	5,925	6,518	65,175	71,693	6.944E+02	5.560E+05	3.736E+01	1.855E+02	2.780E+05	1.868E+01	5.089E+02	2.780E+05	1.868E+01
1985	5,925	6,518	71,100	78,210	7.385E+02	5.914E+05	3.973E+01	1.973E+02	2.957E+05	1.987E+01	5.413E+02	2.957E+05	1.987E+01
1986	5,925	6,518	77,025	84,728	7.802E+02	6.248E+05	4.198E+01	2.084E+02	3.124E+05	2.099E+01	5.718E+02	3.124E+05	2.099E+01
1987	5,925	6,518	82,950	91,245	8.196E+02	6.563E+05	4.410E+01	2.189E+02	3.281E+05	2.205E+01	6.007E+02	3.281E+05	2.205E+01
1988	5,925	6,518	88,875	97,763	8.568E+02	6.861E+05	4.610E+01	2.289E+02	3.430E+05	2.305E+01	6.279E+02	3.430E+05	2.305E+01
1989	5,925	6,518	94,800	104,280	8.919E+02	7.142E+05	4.799E+01	2.382E+02	3.571E+05	2.399E+01	6.537E+02	3.571E+05	2.399E+01
1990	5,925	6,518	100,725	110,798	9.251E+02	7.408E+05	4.977E+01	2.471E+02	3.704E+05	2.489E+01	6.780E+02	3.704E+05	2.489E+01
1991	5,925	6,518	106,650	117,315	9.564E+02	7.659E+05	5.146E+01	2.555E+02	3.829E+05	2.573E+01	7.009E+02	3.829E+05	2.573E+01
1992	5,925	6,518	112,575	123,833	9.860E+02	7.896E+05	5.305E+01	2.634E+02	3.948E+05	2.653E+01	7.226E+02	3.948E+05	2.653E+01
1993	5,000	5,500	118,500	130,350	1.014E+03	8.120E+05	5.455E+01	2.706E+02	4.060E+05	2.728E+01	7.431E+02	4.060E+05	2.728E+01
1994	0	0	123,500	135,850	1.028E+03	8.228E+05	5.528E+01	2.745E+02	4.114E+05	2.764E+01	7.530E+02	4.114E+05	2.764E+01
1995	0	0	123,500	135,850	9.708E+02	7.772E+05	5.222E+01	2.593E+02	3.886E+05	2.611E+01	7.113E+02	3.886E+05	2.611E+01
1996	0	0	123,500	135,850	9.168E+02	7.341E+05	4.933E+01	2.449E+02	3.671E+05	2.466E+01	6.719E+02	3.671E+05	2.466E+01
1997	0	0	123,500	135,850	8.660E+02	6.935E+05	4.659E+01	2.313E+02	3.467E+05	2.330E+01	6.347E+02	3.467E+05	2.330E+01
1998	0	0	123,500	135,850	8.180E+02	6.550E+05	4.401E+01	2.185E+02	3.275E+05	2.201E+01	5.995E+02	3.275E+05	2.201E+01
1999	0	0	123,500	135,850	7.727E+02	6.187E+05	4.157E+01	2.064E+02	3.094E+05	2.079E+01	5.663E+02	3.094E+05	2.079E+01
2000	0	0	123,500	135,850	7.299E+02	5.845E+05	3.927E+01	1.950E+02	2.922E+05	1.963E+01	5.349E+02	2.922E+05	1.963E+01
2001	0	0	123,500	135,850	6.894E+02	5.521E+05	3.709E+01	1.842E+02	2.760E+05	1.855E+01	5.053E+02	2.760E+05	1.855E+01
2002	0	0	123,500	135,850	6.512E+02	5.215E+05	3.504E+01	1.740E+02	2.607E+05	1.752E+01	4.773E+02	2.607E+05	1.752E+01
2003	0	0	123,500	135,850	6.152E+02	4.926E+05	3.310E+01	1.643E+02	2.463E+05	1.655E+01	4.508E+02	2.463E+05	1.655E+01
2004	0	0	123,500	135,850	5.811E+02	4.653E+05	3.126E+01	1.552E+02	2.327E+05	1.563E+01	4.259E+02	2.327E+05	1.563E+01
2005	0	0	123,500	135,850	5.489E+02	4.395E+05	2.953E+01	1.466E+02	2.198E+05	1.477E+01	4.023E+02	2.198E+05	1.477E+01
2006	0	0	123,500	135,850	5.185E+02	4.152E+05	2.790E+01	1.385E+02	2.076E+05	1.395E+01	3.800E+02	2.076E+05	1.395E+01
2007	0	0	123,500	135,850	4.897E+02	3.922E+05	2.635E+01	1.308E+02	1.961E+05	1.317E+01	3.589E+02	1.961E+05	1.317E+01
2008	0	0	123,500	135,850	4.626E+02	3.704E+05	2.489E+01	1.236E+02	1.852E+05	1.244E+01	3.390E+02	1.852E+05	1.244E+01
2009	0	0	123,500	135,850	4.370E+02	3.499E+05	2.351E+01	1.167E+02	1.750E+05	1.176E+01	3.203E+02	1.750E+05	1.176E+01
2010	0	0	123,500	135,850	4.128E+02	3.305E+05	2.221E+01	1.103E+02	1.653E+05	1.110E+01	3.025E+02	1.653E+05	1.110E+01
2011	0	0	123,500	135,850	3.899E+02	3.122E+05	2.098E+01	1.041E+02	1.561E+05	1.049E+01	2.858E+02	1.561E+05	1.049E+01