2021

# HARRISONBURG GHG EMISSIONS REPORT


CITY OF HARRISONBURG PUBLIC WORKS

# CITY OF HARRISONBURG, VIRGINIA

# ICLEI GOVERNMENT EMISSIONS INVENTORY
# 2021 SUMMARY REPORT

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**EXECUTIVE SUMMARY**

The City of Harrisonburg, Virginia, greenhouse gas (GHG) emissions inventory was completed for the calendar year 2021 and compared to the previous analysis for 2016 (baseline year) and 2019. This report is part of Phase 2 of the City of Harrisonburg's Environmental Action Plan (EAP). The GHG emissions inventory was completed at both the Municipal and Community levels.

The scope of the Municipal inventory includes energy (electricity, natural gas, and fuel oil) for City buildings/facilities, electricity for street/traffic lights, diesel/gasoline fuels for City fleet vehicles/equipment and City Transit buses. This scope is focused on areas in which the City has some control of decisions that can affect GHG emissions.

100-yr and 20-yr GWP values were used in the analysis to provide both shorter and longer term perspectives. These different time horizons account for the different lifetime of GHGs in the atmosphere. The primarily difference in the results is the stronger contribution of methane, mainly from leakage in natural gas distribution, for the 20-yr analysis. 100-yr GWP analyses dominate most reports produced by governments and corporations to meet the Paris Agreement international treaty goal to limit global average temperatures to below 2.0, and preferably to 1.5 degrees Celsius, compared to pre-industrial levels. Given the closing window to meet this goal, there is increasing discussion to promote the use of 20-yr GWP analyses and focus more on methane reductions.

The scope of the Community inventory includes energy (electricity and natural gas) split among the following major sectors: Residential, Commercial, Industrial, Municipal, Water & Sewer, and James Madison University (JMU). Community inventory also includes estimated fuel use (gasoline and diesel) for vehicle travel within the City boundaries based on Virginia Department of Transportation (VDOT) traffic counts. GHG emissions from Solid Waste, Water Treatment, and Waste Water Treatment are included in the Community Inventory as well. This scope is focused on the broader Community GHG emissions, which are only indirectly affected by City policies/initiatives and controlled more directly by the activities and behavior of the community as a whole and its members individually.

Total Municipal GHG emissions in 2021 for Harrisonburg were 20,600 metric tons, a 5.2% decrease from the 2016 baseline level using 100-yr GWP values. Buildings/facilities accounted for 39% of these emissions and the dominant fuel source for the City was electricity at 51%. School operations including electricity, natural gas, fuel oil, and diesel fuel (school buses) contribute 30% of all Municipal GHG emissions.

Total Community GHG emissions in 2021 for Harrisonburg were 609,000 metric tons, a 3.4% decrease from the 2016 baseline level using the 100-yr GWP values. The Commercial and Transportation sectors accounted for 30% and 28% of these emissions, respectively, and the dominant fuel source for the Community emissions was electricity at 38%. The Municipal sector accounted for approximately 3.4% of the total Community GHG emissions.

For the 20-yr GWP analysis, total Community GHG emissions in 2021 were 806,000 metric tons, a 1.0% decrease. This smaller reduction in GHG emissions in the 20-year timeframe is primarily due to the higher relative GWP of methane from natural gas leakage and solid waste landfill gas.

This initial report can serve as the basis for further discussions and planning among key stakeholders in both the City and Community to develop action plans for future GHG emissions reductions.

## 1. INTRODUCTION

This report details both the Municipal (City operations) and Community Greenhouse Gas (GHG) emissions for the City of Harrisonburg, VA, for the calendar year 2021. These results are compared to the previous analyses for 2016 (baseline year) and 2019. These emissions are estimated based on the inventory of energy and fuel use for Harrisonburg. The 2020 data set was not considered to be representative of a typical year due to the pandemic based on the changes from normal city operations that were associated with it. In compiling and analyzing the 2021 data, several small errors were found in the 2016/19 assessment. These errors have been fixed and are noted in this report – in data tables these updated data and values are indicated by red text.

This report is part of Phase 2 of the City of Harrisonburg's Environmental Action Plan (EAP). The development of the EAP will be completed in three phases (1, 2, and 3). The EAP consists of six focus areas: (1) Buildings and Energy, (2) Land Use and Green Space, (3) Regional Food Systems, (4) Sustainable Transportation, (5) Waste Reduction and Recycling, and (6) Water Resources. Phase 1 describes goals, co-benefits, and strategies, and identifies tasks and responsible parties. Phase 1 of the EAP was presented to City Council and adopted on January 14, 2020. Phase 2 compiles an inventory of municipal and community activities and links them to energy and GHG emissions to develop a baseline to be used for measuring progress towards achieving goals in the future. This particular analysis includes focus areas (1), (4), and (5). GHG emissions for focus areas (2), (3), and (6) are generally much harder to measure and with fewer direct GHG emissions and are therefore not part of the scope of this analysis. Land use emissions are complex and depend on many factors including the type of land and specific changes from one particular landscape to another. Adding trees to increase the tree canopy also reduces emissions indirectly by shading buildings and lower the urban heat island effects, which results in less cooling needed during warmer months. This is in addition to direct effects of trees acting as GHG emission sinks as carbon dioxide is removed from the air as part of the photosynthesis process. Because trees grow slowly and sequester carbon from the atmosphere, reducing the removal of trees in cities is as important as planting new trees. These baseline indicators provide a snapshot of the current conditions and can be useful for setting actionable and measurable targets. During Phase 3, the City will consider baseline inventory data and GHG emissions to establish targets with statements that define the desired change by a specific year.

Greenhouse gases (GHGs) are chemicals in the atmosphere that absorb radiation and therefore warm the atmosphere and the planet.[1] These gases, which include carbon dioxide, methane, and various refrigerants, are released into the atmosphere by various human activities. GHGs are characterized by a Global Warming Potential (GWP), which quantifies the potential of these chemicals to absorb heat compared to carbon dioxide over a specific time period. Carbon dioxide ($CO_2$) is the dominant GHG in the atmosphere by mass and is emitted due to combustion of fossil fuels including coal, natural gas, heating oil, gasoline, and diesel fuel. Methane emissions are much smaller in amount, but this chemical has a much larger GWP (see table 1) so contributes more significantly than one would expect based only on the amount. Although not the focus of this analysis, the combustion of fossil fuels also leads to additional air pollution including Criteria Air Pollutants (CAPs), which can also harm human health and the environment.

GHGs are strongly linked through scientific research modeling to increasing global temperatures and have been increasing since the industrial revolution. Many cities, states, and countries are developing plans to reduce GHGs and mitigate the expected environmental, economic, and health impacts of global warming and climate change. According to climate scientists and based on thousands of

research studies, the time window for reducing GHG emissions and thereby minimizing the negative effects on human health, the environment, and global economic systems is closing.

The primary goals of a GHG inventory are to understand the sources of GHG emissions within both the community at large and across a City's municipal operations. This information is critical to make effective changes to both policy and practice at the municipal and community levels to reduce these emissions. Without an understanding of the specific sources and magnitude of these emissions, it is impossible to develop plans that are both feasible and cost effective for GHG reductions.

Effectively preparing for and responding to current and projected climate change requires an ongoing evaluation and a series of action steps, not a one-time assessment. It calls on our community to adopt policies and practices that make environmental sustainability and resilience a consideration in all activities and actions taken by our community. It also calls on us to strengthen existing efforts and build partnerships throughout the community to reduce Harrisonburg's vulnerability to the changing environment. The development of the EAP is designed to accomplish this goal. The EAP acknowledges existing city plans, programs and strategies, and builds upon them by proposing measures to accelerate advancements in sustainability, of which economic vitality, environmental protection, and health and well-being are collectively considered to be critical pieces of achieving sustainability goals and reducing greenhouse gas emissions. Adopting and implementing the EAP helps the City support global targets for a stable climate and a resilient community.

There is always a balance between the accuracy/detail and time/effort in this type of analysis. Enough detail is required to identify areas of concern and action, but too much detail can take additional time and effort that either does not provide the necessary resolution or is not required to make broad decisions.

## 2. METHODOLOGY, SCOPE AND ASSUMPTIONS

The ICLEI ClearPath online software analysis (*https://clearpath.icleiusa.org/*) was used for this analysis. The baseline year data in this report is 2016 and 2019 data has been analyzed and reported as well. The 2016/2019 analysis uses the 100-year global warming potentials (GWP) from the Intergovernmental Panel on Climate Change (IPPC) 5$^{th}$ Assessment Report (AR5). Table 1 shows the GWPs for the most common of the emission chemicals for both the 20-yr and 100-yr timeframes.[2]

The 100-yr time horizon and the associated GWP values have been the typical recommendation by the IPCC and most other major reporting platforms recommend that you calculate your footprint using the 100-year GWP for GHG analyses and decision-making. However, continuing research and climate modeling are suggesting that a shorter time horizon may be a better choice for local, national, and international government policies and actions given the scientific recommendations of 50% GHG reductions by 2030 and 100% reductions by 2050. As seen in Table 1, the main difference in the GHG values for the 20-yr time horizon is a much stronger contribution for methane since it has a shorter lifetime in the atmosphere. This means that methane reductions will have a more significant effect on climate change compared to carbon dioxide over this shorter time frame. Note that this does not change the overall climate impact at longer time frames.

| Chemical | IPCC AR5: 20-yr GWP (kg CO2e/kg) | IPCC AR5: 100-yr GWP (kg CO2e/kg) |
|---|---|---|
| Carbon Dioxide ($CO_2$) | 1 | 1 |
| Methane ($CH_4$) | 84 | 28 |
| Nitrous Oxide ($N_2O$) | 264 | 265 |

**Table 1 – Global Warming Potentials from the IPCC 5th reports.**

## 3. MUNICIPAL AND COMMUNITY INVENTORY DATA

### 3a. Electricity

Most of the electricity data was provided by the Harrisonburg Electric Commission (HEC). Municipal Electricity data was provided based on HEC metered accounts in detailed spreadsheets with usage by departments and by month. Grid loss was estimated based on the SRVC regional grid from the EPA eGrid database.[3] The electricity data was sorted by department and a detailed dataset is provided in Appendix 1. Additional electricity data for the Raw Water Pumping Station, Water Treatment Plant, and the Harrisonburg Rockingham Regional Sewage Authority (HRRSA) was added to the HEC data from Dominion Power accounts since these facilities are located outside of the City limits. Because these facilities serve more than just the City, their electricity totals were allocated based on the fraction of City customers. These values were 82% and 56.4%, respectively, for water pumping and treatment for the Sewer Authority in 2021. In the 2016 baseline year, the percentage of water and sewage treatment for the City were 85% and 63%.

A summary of all of the electricity data is provided in Table 2 and in the pie chart in Figure 1. Note that the pie chart does not include categories less than 1%. Electricity is dominated by *Schools* with 36% of the total usage in 2021 followed by Sewer and Water with a combined contribution of 36.9%. Overall, electricity usage decreased 2.2% from 2019 but is 1.4% higher than the 2016 baseline. It should be noted that Bluestone Elementary School was added in 2017 (103,700 $ft^2$) and Elon Rhodes Early Learning Center was added in 2017 (16,000 $ft^2$). The difference calculated in the final columns of Table 2, and throughout the report, is the current year value minus the previous value divided by the previous value, which gives a percent increase or decrease from another year.

| | 2016 | | 2019 | | 2021 | | Difference |
|---|---|---|---|---|---|---|---|
| DEPARTMENT/FUNCTION | kWh | % of Total | kWh | % of Total | kWh | % of Total | 2021 vs 2016 (%) |
| SCHOOLS | 11,364,115 | 36.3% | 12,584,293 | 38.7% | 11,439,828 | 36.0% | 0.7% |
| SEWER AUTHORITY | 7,260,657 | 23.2% | 7,304,352 | 22.5% | 7,951,502 | 25.0% | 9.5% |
| WATER DEPT, TREATMENT, & PUMPING | 3,524,084 | 11.2% | 3,442,868 | 10.6% | 3,775,230 | 11.9% | 7.1% |
| TRAFFIC & STREET LIGHTS | 3,026,731 | 9.7% | 3,041,823 | 9.4% | 2,998,843 | 9.4% | -0.9% |
| RECREATION DEPT | 1,770,972 | 5.6% | 1,771,940 | 5.5% | 1,520,684 | 4.8% | -14.1% |
| FIRE DEPT | 1,621,085 | 5.2% | 1,777,509 | 5.5% | 1,682,096 | 5.3% | 3.8% |
| TRANSPORTATION DEPT | 1,088,028 | 3.5% | 891,593 | 2.7% | 742,191 | 2.3% | -31.8% |
| COMMUNITY DEVELOPMENT* | 790,385 | 2.5% | 771,089 | 2.4% | 789,400 | 2.5% | -0.1% |
| PUBLIC WORKS | 375,779 | 1.2% | 410,153 | 1.3% | 405,317 | 1.3% | 7.9% |
| PARKING SERVICES | 264,139 | 0.8% | 238,848 | 0.7% | 226,148 | 0.7% | -14.4% |
| EMERGENCY COMMUNICATIONS CENTER (HREC | 189,058 | 0.6% | 217,225 | 0.7% | 204,618 | 0.6% | 8.2% |
| CENTRAL STORES | 65,086 | 0.2% | 46,264 | 0.1% | 36,391 | 0.1% | -44.1% |
| POLICE DEPT | 6,819 | 0.02% | 10,014 | 0.03% | 10,878 | 0.03% | 59.5% |
| **TOTALS** | **31,346,938** | **100%** | **32,507,971** | **100%** | **31,783,126** | **100%** | **1.4%** |
| ELECTRICITY GRID LOSS (%) | 4.5% | | 5.1% | | 5.3% | | |
| ELECTRICITY GRID LOSS (4.5%) | 1,410,612 | | 1,657,907 | | 1,684,506 | | |
| **City Hall Complex* | | | | | | | |

**Table 2 – Harrisonburg Municipal Electricity Usage by Department/Function**

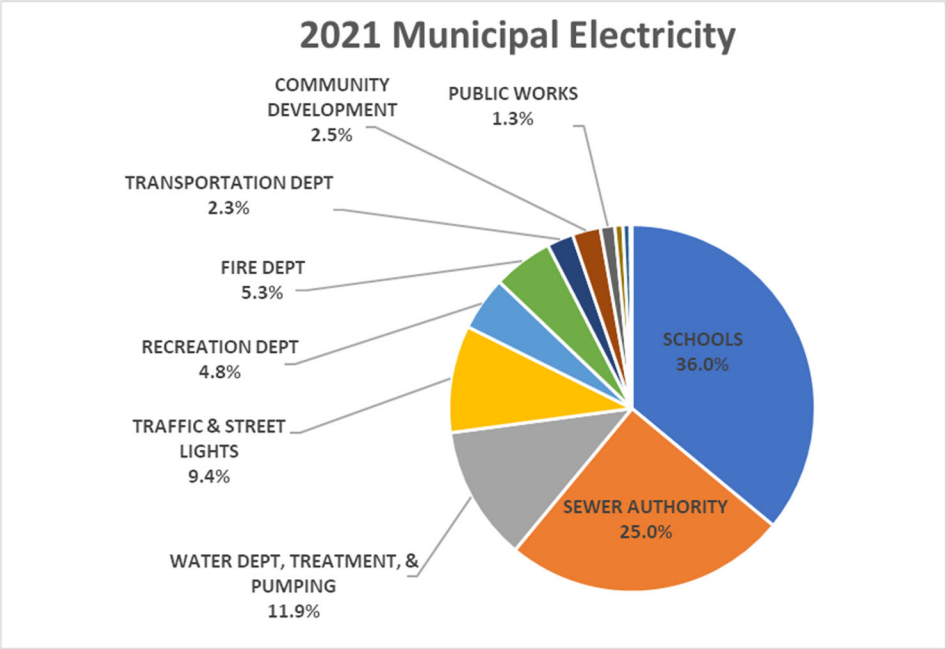


**Figure 1 – Harrisonburg 2021 Municipal Electricity Pie Chart by Department/Function**

As the largest electricity user, the Schools category for electricity usage was further broken down in Table 3 and Figure 2. Harrisonburg High School used 32% of the school system electricity in 2021. School system electricity increased approximately less than 1% from 2016 to 2021, with more than a 9% decrease from 2019. Note that Thomas Harrison Middle School also has a relatively small 2.4 kW Skystream wind turbine which generates electricity that offsets this school's electricity usage. Wind speed and energy-generation data for this wind turbine can be found at *https://openei.org/wiki/Thomas_Harrison_Middle_School Wind_Project.* This turbine has generated approximately 22,000 kWh to date.

| School Summary | | | 2016 | | 2019 | | 2021 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Account | School | Address | kWh | Total | kWh | Total | kWh | Total | 2021 (%) | Δ 2016 | Δ 2019 |
| 13653-27 | Harrisonburg High School | 1001 GARBERS CHURCH RD | 1,324,800 | | 1,469,760 | | 1,202,880 | | | | |
| 13653-28 | Harrisonburg High School | 1001 GARBERS CHURCH RD | 1,826,880 | | 2,322,240 | | 2,148,480 | | | | |
| 13653-29 | Harrisonburg High School Stadium | 1001 GARBERS CHURCH RD | 178,944 | | 188,544 | | 139,776 | | | | |
| 13653-35 | Harrisonburg High School | 1001 GARBERS CHURCH RD | 17,161 | | 35,931 | | 31,018 | | | | |
| 13653-36 | Harrisonburg High School | 1001 GARBERS CHURCH RD | 17,920 | | 54,160 | | 40,960 | | | | |
| 13653-38 | Harrisonburg High School | 1001 GARBERS CHURCH RD | - | | 54,240 | | 37,200 | | | | |
| 13653-39 | Harrisonburg High School | 1001 GARBERS CHURCH RD | - | | 26,960 | | 23,680 | | | | |
| 13653-40 | Harrisonburg High School | 1001 GARBERS CHURCH RD | - | | 24,800 | | 24,080 | | | | |
| 13653-41 | Harrisonburg High School | 1001 GARBERS CHURCH RD | - | **3,365,705** | - | **4,176,635** | 27,815 | **3,675,889** | **32.1%** | **9.2%** | **-12.0%** |
| | Smithland Elementary School/Skyline Middle | | | | | | | | | | |
| 13653-33 | School/Elon Rhodes Early Learning Center | 470 LINDA LN | 2,344,320 | **2,344,320** | 2,453,760 | **2,453,760** | 2,365,440 | **2,365,440** | **20.7%** | **0.9%** | **-3.6%** |
| 13653-19 | Thomas Harrison Middle School | 1311 W MARKET ST | 1,819,200 | **1,819,200** | 1,350,720 | **1,350,720** | 1,080,000 | **1,080,000** | **9.4%** | **-40.6%** | **-20.0%** |
| 13653-6 | Stone Spring Elementary School | 1575 PEACH GROVE AVE | 1,008,960 | | 1,123,200 | | 987,840 | | | | |
| 13653-7 | Stone Spring Elementary School | 1575 PEACH GROVE AVE | 16,290 | | 32,443 | | 13,305 | | | | |
| 13653-8 | Stone Spring Elementary School | 1575 PEACH GROVE AVE | 66,435 | | 79,557 | | 63,260 | | | | |
| 13653-30 | Stone Spring Elementary School | 1575 PEACH GROVE AVE | 34,726 | **1,126,411** | 43,742 | **1,278,942** | 44,371 | **1,108,776** | **9.7%** | **-1.6%** | **-13.3%** |
| 13653-14 | Spotswood Elementary School | 375 S CARLTON ST | 191,760 | | 193,000 | | 192,560 | | | | |
| 13653-15 | Spotswood Elementary School | 375 S CARLTON ST | 563,520 | | 622,560 | | 535,120 | | | | |
| 13653-16 | Spotswood Elementary School | 375 S CARLTON ST | 46,257 | | 47,627 | | 55,387 | | | | |
| 13653-17 | Spotswood Elementary School | 400 MOUNTAIN VIEW DR | 27,297 | **828,834** | 21,047 | **884,234** | 16,948 | **800,015** | **7.0%** | **-3.5%** | **-9.5%** |
| 13653-3 | Keister Elementary School | 100 MARYLAND AVE | 514,560 | | 516,480 | | 524,160 | | | | |
| 13653-4 | Keister Elementary School | 100 MARYLAND AVE | 101,777 | | 93,023 | | 104,588 | | | | |
| 13653-5 | Keister Elementary School | 100 MARYLAND AVE | 222,240 | **838,577** | 237,840 | **847,343** | 230,640 | **859,388** | **7.5%** | **2.5%** | **1.4%** |
| 13653-20 | Waterman Elementary School | 451 CHICAGO AVE SEC LIGH | 6,300 | | 6,300 | | 6,300 | | | | |
| 13653-21 | Waterman Elementary School | 451 CHICAGO AVE | 714,240 | | 718,560 | | 709,200 | | | | |
| 13653-22 | Waterman Elementary School | 451 CHICAGO AVE | 52,785 | | 55,653 | | 52,166 | | | | |
| 13653-23 | Waterman Elementary School | 451 CHICAGO AVE | 46,943 | **820,268** | 47,726 | **828,239** | 51,634 | **819,300** | **7.2%** | **-0.1%** | **-1.1%** |
| 13653-37 | Bluestone Elementary School | 750 GARBERS CHURCH RD | - | - | 536,100 | **536,100** | 516,300 | **516,300** | **4.5%** | | **-3.7%** |
| 13653-34 | School Board Office | 1 COURT SQ | 220,800 | **220,800** | 228,320 | **228,320** | 214,720 | **214,720** | **1.9%** | **-2.8%** | **-6.0%** |
| **Totals** | | | **11,364,115** | **11,364,115** | **12,584,293** | **12,584,293** | **11,439,828** | **11,439,828** | **100%** | **0.7%** | **-9.1%** |

* Bluestone Elementary School and Elon Rhodes Early Learning Center first opened in August 2017

**Table 3 – Harrisonburg School Electricity Usage by School**

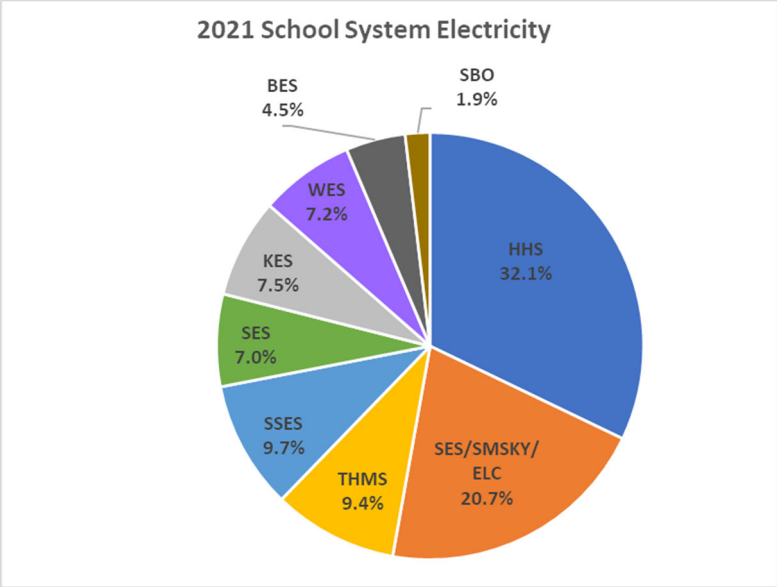


**Figure 2 – Harrisonburg School Electricity Pie Chart**

Community-wide electricity for Harrisonburg was provided by Brian O'Dell at HEC and is shown in Table 4 and Figure 3. The Residential sector includes all residential users while the Industrial sector includes all customers with a demand of 1000 kW or greater. JMU includes all accounts in the name of the university including the JMU Foundation, even those not located on the main campus. The Commercial sector consists of all non-Residential accounts that do not fall into any of the aforementioned categories. For future reference and data consistency, the Commercial electricity value is the sum of Rates 206, 314 and 315 and Industrial value is the sum of Rates 525 and 405. The Municipal sector includes all HEC accounts on the Municipal rate except the Water Department electricity and Sewer Flume Station which were included under the Water & Sewer sector along with the Water Treatment, Raw Water Pumping, and Sewer Authority electricity from Dominion accounts.

The electricity data shows an overall small decrease in electricity use of 0.7% for 2021 compared to 2016. In 2021, the Commercial sector and Residential sectors both contributed approximately 31% while Industrial and JMU were each approximately 17%. Note that while Municipal electricity is the sector that the City has the most control over, it contributed only 3% of the total Community usage. Electricity usage for JMU and the residential sector both increased in 2021 compared to 2016. This increase is not due to additional cooling in the summer via heat pumps or air conditioning units as the total cooling degree days (CDD) were 1042, 1140, and 971 respectively for 2016, 2019, and 2021. CDD estimate the amount of cooling needed by comparing the average daily temperature to a setpoint of 65 $^{o}$F and summing the temperature differences across the entire year.

| | Electricity Sector | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Residential (kWh) | Commercial (kWh) | Industrial (kWh) | Municipal* (kWh) | JMU (kWh) | Water & Sewer (kWh) | Totals (kWh) | Grid Loss (%) | Grid Loss (kWh) |
| 2016 | 197,228,099 | 232,571,151 | 117,197,400 | 20,562,197 | 115,370,687 | 10,784,741 | 693,714,275 | 4.5% | ***31,217,142*** |
| 2019 | 207,255,483 | 234,960,057 | 116,416,689 | 21,760,751 | 113,493,551 | 10,747,220 | 704,633,751 | 5.1% | ***35,936,321*** |
| 2021 | 212,213,233 | 214,253,579 | 112,928,760 | 20,056,394 | 117,749,833 | 11,726,732 | 688,928,531 | 5.3% | ***36,513,212*** |
| **% Difference (2021 to 2016)** | **7.6%** | **-7.9%** | **-3.6%** | **-2.5%** | **2.1%** | **8.7%** | **-0.7%** | **17.8%** | **17.0%** |
| **Sector (%) 2021** | **30.8%** | **31.1%** | **16.4%** | **2.9%** | **17.1%** | **1.7%** | **100%** | | |

**Table 4 – Harrisonburg Community Electricity Usage by Sector**

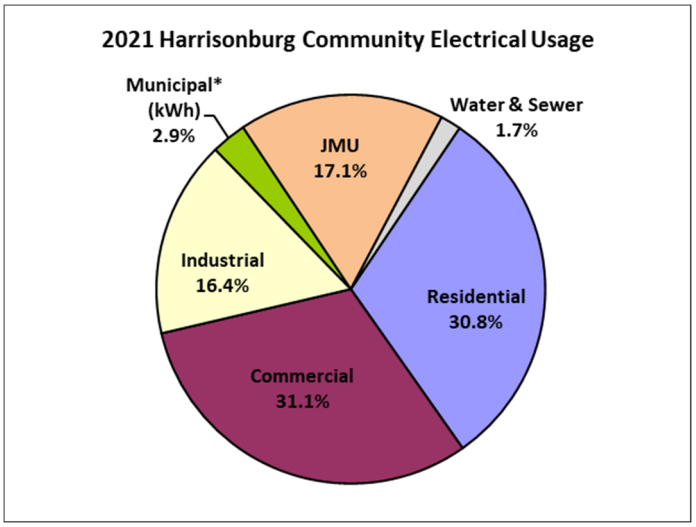


**Figure 3 – Harrisonburg 2021 Community Electricity Pie Chart by Sector**

Harrisonburg electricity is provided through the HEC by Dominion Energy from the generation mix they have across the regional grid. Carbon dioxide emissions factors for 2019 and 2021 were obtained from the Edison Electric Institute EEI database from the Utility Specific Residual Mix Emissions Rate column.[4] The 2019 carbon dioxide emissions value, shown in red in Table 5, is updated from the previous report to more accurately account for energy that comes from outside of Dominion Power. The 2016 CO2 factor remains the same in this report since the more accurate EEI database was started after this date. This EEI database does not include methane and nitrous oxide emissions factors or grid losses so the EPA eGrid[3] values for the Southeast Region Virginia Carolina (SRVC) regional electricity grid were used - 2020 data were used as the 2021 data are not yet published. These differences are expected to be very small. These parameters are summarized in Table 5 and are the inputs for the ClearPath *Electricity Factor Sets*. More details from the regional grid emissions are provided in Appendix 2 noting that the carbon dioxide factors are somewhat different for Dominion Energy of Virginia compared to the entire SRVC region. The Transmission and Distribution (T&D) grid loss which is electricity lost due to resistance and inefficiencies between the power plant and the final electricity use, is included in both the Municipal and Community-level assessments based on the total electricity usage for each case.

| | Electricity Emission Factors (lb/MWh) | | |
|---|---|---|---|
| **Chemical** | **2016** | **2019** | **2021** |
| $CO_2$ | 745[5] | 751[4] | 693[4] |
| $CH_4$ | 0.067 | 0.058 | 0.050[3] |
| $N_20$ | 0.011 | 0.008 | 0.007[3] |
| Grid Loss (%) | 4.5 | 5.1[3] | 5.3[3] |

[3]*Most recent EPA eGrid data (2020)*
[4]*EEI Database, Edison Electric Institute*
[5]Dominion Energy 2019 Sustainability and Corporate Responsibility Report

**Table 5 –Emissions Factors from Dominion Energy and EPA eGrid (SRVC) database**

Table 6 shows the fuel mix for delivered Dominion Power Virginia Electricity[4]. The 2019 data was reported a bit differently so the fuel source percentages are lower since the fuel mix for Purchased Electricity is not detailed. Coal is generally being replaced by natural gas in recent years due to higher supply and local costs. In 2020, electricity produced from coal in the US had an average emissions factor of 2230 lb $CO_2$/MWh compared to 910 lb $CO_2$/MWh for natural gas.[6] The emissions values in table 5 and 6 are decreasing and less than both of these fossil fuels due to the lower carbon emissions of nuclear and renewable fuel sources. Note that these emissions factors are only for the generation and use stages of the life cycle of electricity and do not account for upstream (mining, processing and fuel transportation) or downstream (waste disposal) emissions.

| Year | 2019 | 2020 | 2021 |
|---|---|---|---|
| Total Electricity Delivered (MWh) | 86,474,382 | 83,282,826 | 90,013,155 |
| Utility Specific Residual Mix Emissions Rate (lbs/MWh) | 751 | 712 | 693 |
| Coal | 7.9% | 19.3% | 8.8% |
| Natural Gas | 42.3% | 47.8% | 49.2% |
| Nuclear | 30.5% | 22.2% | 32.4% |
| Petroleum | 0.1% | 0.0% | 0.1% |
| Biomass/Biogas | 1.1% | 0.0% | 0.9% |
| Geothermal | 0.0% | 0.0% | 0.0% |
| Hydroelectric | 0.8% | 1.9% | 0.9% |
| Solar | 0.1% | 0.0% | 0.5% |
| Wind | 0.0% | 0.0% | 0.0% |
| Other | | 8.8% | 7.2% |
| Purchased Power | 17.2% | | |
| | 100.0% | 100.0% | 100.0% |

**Table 6 – Electricity Fuel Mix from delivered electricity from Dominion Power Virginia[4]**

### 3b. Natural Gas

Natural gas data came from a City spreadsheet compiled from Usage History graphs provided in gas company account bills and a *City Public Schools Utilities* spreadsheet. The data is summarized in Table 7. Figure 4 shows a breakdown of the natural gas usage for 2021. The school data was provided in units of hundred cubic feet (ccf) of natural gas and converted to therms using a gas utility bill conversion factor of 1.0639 therms/ccf. Overall, the Municipal natural gas usage decreased by more than 13% for 2021 compared to the 2016 baseline. Usage is down in all subcategories. Schools dominate natural gas usage at approximately 60% in 2021 with the Department of Parks and Recreation following at approximately 20%, the Fire Department at approximately 9%, and the rest of the categories all less than 5%.

| | | 2016 | | 2019 | | | 2021 | | | Difference |
|---|---|---|---|---|---|---|---|---|---|---|
| **Building & Address** | **Meter #** | **Therms** | | **Therms** | | **% of Total** | **Therms** | | **% of Total** | **2021 - 2016 (%)** |
| Schools - Smithland Elementary & Skyline Middle School (SMSKY) | | 46,896 | | 58,701 | | 15.5% | 56,937 | | 15.7% | |
| Schools - Stone Spring Elementary School (SSES) | | 38,457 | | 42,151 | | 11.2% | 45,501 | | 12.5% | |
| Schools - Thomas Harrison Middle School (TMHS) | | 80,111 | | 34,565 | | 9.2% | 27,081 | | 7.5% | |
| Schools - Spotswood Elementary School (SES) | | 27,686 | | 32,140 | | 8.5% | 30,009 | | 8.3% | |
| Schools - Keister Elementary School (KES) | | 24,105 | | 29,830 | | 7.9% | 30,398 | | 8.4% | |
| Schools - Waterman Elementary School (WES) | | 21,044 | | 21,728 | | 5.8% | 20,477 | | 5.6% | |
| Schools - Maintenance Building | | 4,858 | | 5,563 | | 1.5% | 4,981 | | 1.4% | |
| Schools - School Board Office (SBO) | | 1,687 | | 1,485 | | 0.4% | 1,288 | | 0.4% | |
| Schools - Harrisonburg High School (HHS) | | 0 | | 0 | | 0.0% | 0 | | 0.0% | |
| Schools - Bluestone Elementary School (BES) | | 0 | | 0 | | 0.0% | 0 | | 0.0% | |
| Schools - Elon Rhodes Early Learning Center (ELC) | | 0 | | 0 | | 0.0% | 28 | | 0.0% | |
| Schools - High School Stadium | | 0 | 244,843 | 0 | 226,163 | 0.0% | 0 | 216,700 | 0.0% | -11.5% |
| Parks & Rec - Westover Pool - 305 S. Dogwood Dr | 901118 | 48,620 | | 35,058 | | 9.3% | 40,824 | | 11.3% | |
| Parks & Rec - Lucy Simms - 620 Simms Ave | M4700071 | 27,996 | | 26,268 | | 7.0% | 22,263 | | 6.1% | |
| Parks & Rec - Community Activities Center - 305 S. Dogwood Dr | 9013433 | 6,808 | | 5,982 | | 1.6% | 7,648 | | 2.1% | |
| Parks & Rec - Golf Course Maintenace 1583 W. Market St B | 6112198 | 3,857 | 87,281 | 3,298 | 70,606 | 0.9% | 2,258 | 72,993 | 0.6% | -16.4% |
| Fire Department - Public Safety Building - 101 N. Main St. | 8461631 | 28,581 | | 32,459 | | 8.6% | 25,757 | | 7.1% | |
| Fire Department Station #1 80 Maryland Ave | M8600409 | 1,895 | | 4,613 | | 1.2% | 4,540 | | 1.3% | |
| Fire Department Station #1 Annex 90 Maryland Ave | U766302 | 1,048 | 31,524 | 1,104 | 38,176 | 0.3% | 1,098 | 31,395 | 0.3% | -0.4% |
| Transportation - Central Garage - 473 E. Washington St | 13600365 | 24,909 | | 15,097 | | 4.0% | 15,405 | | 4.2% | |
| Transportation - Administration Building - 475 E. Washington St | 10600339 | 269 | 25,178 | 282 | 15,379 | 0.1% | 251 | 15,656 | 0.1% | -37.8% |
| Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 3 | 6074588 | 4,745 | | 4,899 | | 1.3% | 4,306 | | 1.2% | |
| Public Works - Central Stores Warehouse - 2111 Beery Rd | M6600026 | 2,973 | | 3,833 | | 1.0% | 3,405 | | 0.9% | |
| Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 4 | 97800115 | 3,168 | | 2,779 | | 0.7% | 3,218 | | 0.9% | |
| Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 1 | R171893 | 3,821 | | 2,451 | | 0.6% | 2,177 | | 0.6% | |
| Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 2 | M7400649 | 1,841 | | 1,624 | | 0.4% | 1,313 | | 0.4% | |
| Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 5 | 9277707 | 939 | 17,487 | 744 | 16,330 | 0.2% | 919 | 15,338 | 0.3% | -12.3% |
| General Properties - City Hall - 409 S. Main St | M7900196 | 4,582 | 4,582 | 4,458 | 4,458 | 1.2% | 4,234 | 4,234 | 1.2% | -7.6% |
| Water Department 2155 Beery Rd | 9015735 | 3,946 | 3,946 | 3,482 | 3,482 | 0.9% | 3,449 | 3,449 | 1.0% | -12.6% |
| Tourism - Hardesity Higgins House - 212 S. Main St | M4490516 | 3,598 | 3,598 | 2,914 | 2,914 | 0.8% | 2,832 | 2,832 | 0.8% | -21.3% |
| Harrisonburg Water Pump House 1790 Reservoir St | 3345924 | 207 | 207 | 113 | 113 | 0.0% | 107 | 107 | 0.0% | -48.3% |
| **Totals** | | **418,646** | **418,646** | **377,621** | **377,621** | **100%** | **362,704** | **362,704** | **100%** | **-13.4%** |

**Table 7 – Harrisonburg Municipal Natural Gas Usage**

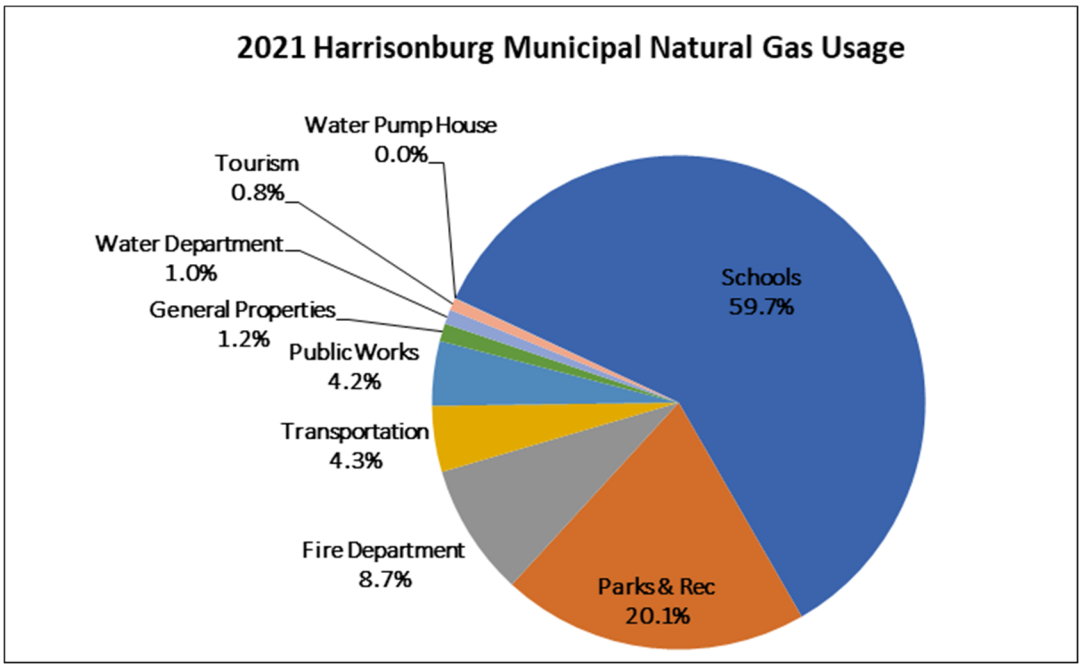


**Figure 4 – Harrisonburg Municipal Natural Gas Usage 2021**

Community-level natural gas usage for Harrisonburg was provided by NiSource Inc., the utility parent company of Columbia Gas of Virginia, which supplies natural gas to the City. The data provided is delineated by the City of Harrisonburg tax district.

The Community-wide natural gas data is summarized in Table 8 and Figure 5. It shows an overall increase in natural gas use from 2021 compared to 2016 of 1.2%. In 2021 the Commercial sectors was the largest at 37.7% and it includes the municipal natural gas usage detailed above, which was only 1.8% of the total Community-wide usage. This increase is not due to additional winter heating as the total heating degree days (HDD) were 4922, 4746, and 4727 respectively for 2016, 2019, and 2021. HDD estimate the amount of heating needed by comparing the average daily temperature to a setpoint of 65 $^{o}$F and summing the temperature differences across the entire year.

| Year | Residential (therms) | Commercial (therms) | JMU (therms) | Industrial (therms) | Totals (therms) |
|---|---|---|---|---|---|
| 2016 | 1,733,830 | 6,379,270 | 7,837,770 | 4,531,220 | 20,482,090 |
| 2019 | 1,944,600 | 8,056,610 | 6,873,850 | 4,597,840 | 21,472,900 |
| 2021 | 1,910,455 | 7,818,585 | 5,923,260 | 5,077,554 | 20,729,854 |
| **Sector (%)** | 9.2% | 37.7% | 28.6% | 24.5% | 100% |
| **Baseline Difference** | 10.2% | 22.6% | -24.4% | 12.1% | 1.2% |

**Table 8 – Harrisonburg Community Natural Gas Usage**

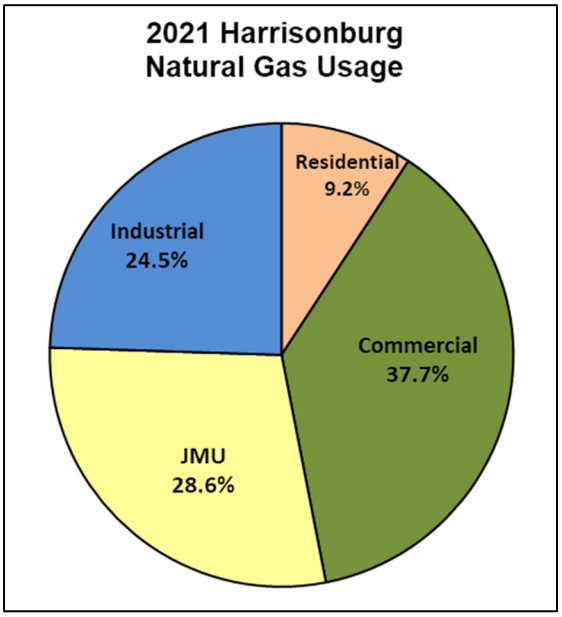


**Figure 5 – Harrisonburg Community Natural Gas Usage by Sector**

### 3c. Natural Gas Leakage

Methane emissions associated with natural gas leakage due to upstream mining, processing, and distribution are included in both the Municipal or Community-wide assessment in the ClearPath software under the *Process and Fugitive Emissions* main tab and *Fugitive Emissions From Natural Gas Distribution* subcategory. The source of GHGs is growing in the public's awareness in recent years. The total direct municipal natural gas consumption above was used along with the indirect natural gas estimates back-calculated from utility electricity production and the fuel mix. From Dominion data in Table 6, the input fuel % for natural gas used for electricity was 35.4%, 41.8% and 40.5% in 2016, 2019,

and 2021, respectively. Leakage was assumed at 4% for municipal gas distribution and 2% for utility natural gas use for electricity production based on a number of recent references.[7-9] Several other assumptions had to be made for these estimates including the density of natural gas at 0.713 kg/m$^3$, energy density of 1.037 MMBtu/MCF, and a composition of 99% methane in natural gas which is on the high end of typical gas sources but more accurate for this analysis since the other contaminants in natural gas are often hydrocarbons which also release carbon dioxide upon combustion.[10-11]

### 3d. Fuel Oil

Municipal use of Fuel Oil was reported for several of the City schools for heating and is detailed in Table 9. These values came from the Public School Utilities spreadsheet and Fiscal Year data was combined to get Calendar Year values. Other municipal uses of fuel oil were considered minimal and not assessed in this report.

| | Fuel Oil Usage (gallons) | | | Difference |
|---|---|---|---|---|
| **Location** | **2016** | **2019** | **2021** | **2019 – 2016 (%)** |
| Harrisonburg High School (HHS) | 49,462 | 54,222 | 62,911 | 9.6 |
| Smithland Elementary & Skyline Middle School (SMSKY) | 79 | 0 | 0 | -100 |

**Table 9 – Harrisonburg Municipal Fuel Oil Usage**

Community-wide use of Fuel Oil for heating is difficult to measure directly and accurately since this fuel is purchased directly from various commercial suppliers by individual residents and business owners. However, the use of heating oil is too large to omit from this analysis so an estimate was used. Use of propane and wood for heating were omitted as the census data shows much lower use at 227 and 100 households, respectively, out of more than 16,700 households in the City. Residential fuel oil use was estimated since consumption averages are reasonable for a large sample of households. This analysis does not include Commercial and Industrial fuel oil use since good estimates were not available for these sectors, which are much more variable than residential housing. The 2020 Census database estimates 5.6% of total Harrisonburg households using fuel oil for heating as shown in the table 10.[12] The 2021 Census data was not yet available at the time of this analysis. The Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS) in 2015 estimates fuel oil/household energy use for the South Atlantic region, which is representative for Harrisonburg.[13] The same values were used for all years since the RECS survey is only done every 5 years. Using a conversion factor of 139,000 BTU per gallon for fuel oil provided a conversion to the average gallons/household of fuel oil for ClearPath.

| Year | Total Households | Households Heating w/ Fuel Oil[11] | Average Annual Fuel Oil/Household[12] (Million BTU) | Average Annual Fuel Oil/Household (gallons) | Total Fuel Use (gallons) |
|---|---|---|---|---|---|
| 2016 | 16,626 | 1,530 | 47.6 | 342 | 523,000 |
| 2019 | 16,723 | 1,121 | 47.6 | 342 | 383,000 |
| 2021 | 16,751 | 938 | 47.6 | 342 | 320,796 |

**Table 10 – Harrisonburg Community Fuel Oil Usage Estimates**

### 3e. Vehicle Transportation and Equipment Fuels

Municipal fuel use (diesel and gasoline) was compiled from the Harrisonburg *Equipment Gallon, Equipment Class* report (EGEC) and a Fuel Summary reports. A summary and graph of this data is shown in Table 11 and Figure 6. The detailed analysis tables are provided in a supplemental appendix rather than this report given the large amount of data. The EGEC report details the Equipment number by class with the total amount of fuel gallons used for each vehicle. The fuel type column lists the primary type of fuel assigned, but could have other types assigned to the vehicle. For some of the diesel fuel fleet vehicles, diesel exhaust fluid (DEF) gallons were also reported. This fluid is added to diesel exhaust emissions to reduce nitrogen oxide ($NO_x$) emissions from diesel exhaust and is not considered in the GHG emissions. No biofuels were used in the municipal fleet.

Diesel transit buses are the largest fleet contributor at 33% of the GHG emissions. Gas fleet vehicles and diesel school buses also contribute significantly at approximately 20% and 13%, respectively. There are large differences in 2021 from the 2016 baseline with some categories down significantly (gas vehicles, diesel school buses, and diesel equipment), other categories higher (gas paratransit and diesel fire trucks/ambulances), and the whole fleet category has 6% lower emissions from the baseline.

| | 2016 | | 2019 | | 2021 | | 2021 | Difference |
|---|---|---|---|---|---|---|---|---|
| **Vehicle/Equipment Fuels** | **Gallons** | **%** | **Gallons** | **%** | **Gallons** | **%** | **Count** | **2021 - 2016 (%)** |
| Diesel Transit Buses | 177,985 | 31.7% | 188,625 | 32.1% | 174,600 | 33.1% | 45 | -1.9% |
| Gas Fleet Vehicles | 121,920 | 21.7% | 118,590 | 20.2% | 104,625 | 19.8% | 257 | -14.2% |
| Diesel School Buses | 89,569 | 15.9% | 98,518 | 16.8% | 67,379 | 12.8% | 117 | -24.8% |
| Diesel Fleet Trucks | 60,231 | 10.7% | 58,749 | 10.0% | 63,864 | 12.1% | 35 | 6.0% |
| Diesel Equipment | 34,439 | 6.1% | 37,658 | 6.4% | 24,180 | 4.6% | 60 | -29.8% |
| Gas Police Vehicles | 28,939 | 5.1% | 37,597 | 6.4% | 40,311 | 7.6% | 46 | 39.3% |
| Gas ParaTransit Buses | 21,208 | 3.8% | 24,833 | 4.2% | 25,270 | 4.8% | 12 | 19.2% |
| Diesel Fire Trucks/Ambulances | 23,728 | 4.2% | 19,490 | 3.3% | 20,526 | 3.9% | 16 | -13.5% |
| Gas Equipment | 4,070 | 0.7% | 3,417 | 0.6% | 6,949 | 1.3% | 38 | 70.7% |
| **TOTALS** | **562,089** | **100%** | **587,477** | **100%** | **527,703** | **100%** | **626** | **-6.1%** |

**Table 11 – Harrisonburg Municipal Fleet Vehicle/Equipment Fuel Usage**

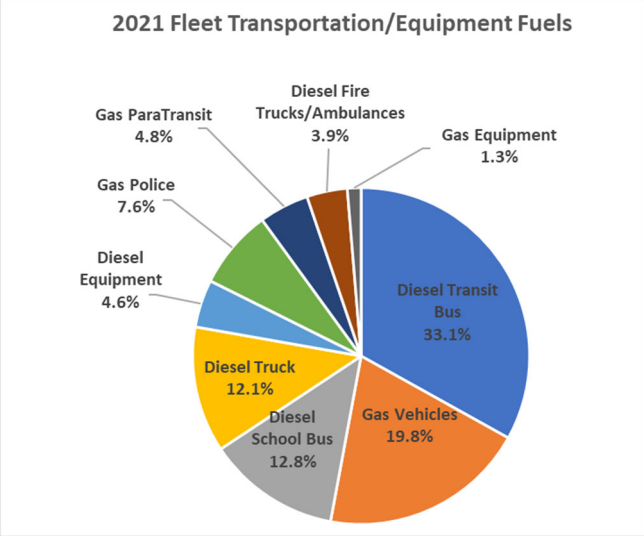


**Figure 6 – Harrisonburg Vehicle/Equipment Fuel Usage**

For Community-wide fuel use, the transportation sector was analyzed using Vehicle Miles Travelled (VMT) data from the 2016, 2019, and 2021 Virginia Department of Transportation (VDOT) report 1220.[14] Daily VMT was measured through VDOT traffic counts and were multiplied by 365 days to determine the Annual VMT. Table 12 provides a summary of the VMT by Road Type. 2021 VMT was 6.3% lower than the 2016 baseline. Miles driven on the I-81 through Harrisonburg are the largest category at 40% as shown in Figure 7, with Primary roads at 32%, and Secondary Roads at 27%. VMT values were converted to emissions using the default US National Vehicle Fuel economy and emissions factor sets provided in ClearPath. VDOT federal vehicle class info from Report 1220 was again used for the percentage of the vehicle types shown in Table 13. This data does not distinguish fuel type for passenger and light trucks which were all assigned gasoline while diesel was assumed for all heavy trucks. More vehicle categories were available in ClearPath as seen in Appendix 3, but the additional detail was not considered to make enough differences for the additional analysis. Fuel economies (gallons/mile) and GHG emissions (grams $CH_4$/mile and grams $N_20$/mile) by vehicle types provided the conversion from VMT to gallons of fuel and GHG emissions.

| | DVMT By Road Type (miles) | | | | Annual | Difference |
|---|---|---|---|---|---|---|
| Year | Secondary | Primary | Interstate | Total | VMT (miles) | (%) |
| 2016 | 255,020 | 304,428 | 358,494 | 917,942 | 335,048,830 | baseline |
| 2019 | 264,760 | 302,838 | 382,063 | 949,661 | 346,626,265 | 3.5% |
| 2021 | 235,384 | 278,385 | 346,136 | 859,906 | 313,865,545 | -6.3% |

**Table 12 – VDOT VMT data for Harrisonburg in 2016, 2019, and 2021.**

| Sub Totals | Fuel | VMT (%) | Federal Vehicle Class | # | Clear Path Label |
|---|---|---|---|---|---|
| 273,787,755 | Gasoline | 0.2% | Motorcycles | 01 | Motorcycles |
| | | 70.2% | Passenger Cars | 02 | Passenger Cars |
| | | 16.8% | Two Axle, 4 Tire Single Unit Vehicles | 03 | Light Trucks |
| | | 87.2% | Gasoline Subtotal | | |
| 40,077,790 | Diesel | 0.5% | Busses | 04 | Heavy Trucks |
| | | 1.0% | Two Axle, 6 Tire Single Unit Trucks | 05 | |
| | | 0.7% | Three Axle Single Unit Trucks | 06 | |
| | | 0.1% | Four or More Axle Single Unit Trucks | 07 | |
| | | 0.5% | Four Axle or Fewer Single Trailers | 08 | |
| | | 9.1% | Five Axle Single Trailers | 09 | |
| | | 0.1% | Six or More Axle Single Trailers | 10 | |
| | | 0.4% | Five Axle or Fewer Multi-Trailers | 11 | |
| | | 0.3% | Six Axle Multi-Trailers | 12 | |
| | | 0.0% | Seven or More Axle Multi-Trailers | 13 | |
| | | 12.8% | Diesel Subtotal | | |
| **313,865,545** | | **100.0%** | **Total Transportation** | | |

**Table 13 – VDOT Vehicle Percentages in 2021.**

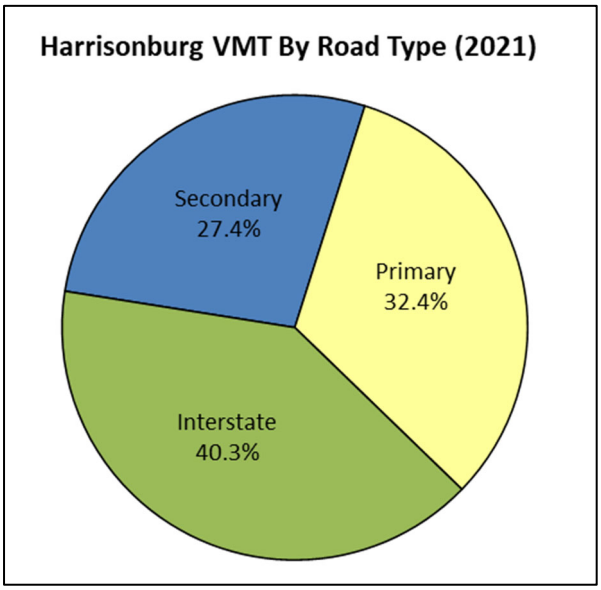


**Figure 7 – Harrisonburg Vehicle Miles Traveled By Road Type (2021)**

## 3f. Waste Disposal

Harrisonburg City Community solid waste is sent to the Rockingham County Landfill. Waste tonnage data was obtained from the Area MSW Annual Data spreadsheet provided by Harsit Patel, Support Services Manager in the City of Harrisonburg Department of Public Works. The data is summarized in Table 14 for 2016, 2019, and 2021. Even though the solid waste is broken down by several categories, the Mixed Solid Waste (MSW) default (100%) method in ClearPath based on the EPA WARM v14 model was used since these waste data categories do not match up well with the detailed categories in the ClearPath Waste Factor sets. The default waste percentages are based on the US municipal averages since specific waste percentages were not available for the City of Harrisonburg municipal waste. These differences are important in the interpretation of the landfill methane in the 20-yr GHG totals. Municipal solid waste was not analyzed due to the lack of detailed waste data at the Municipal level.

| Harrisonburg City Waste | Municipal Solid Waste (residential refuse) | Commerical Refuse[1] | Non-chargeable on report | Concrete, Dirt, Rock | Construction/ Demolition/ Wood Debris | Industrial Waste[2] | Vegetative/ Yard Waste[3] | Unsorted Rubbish | Sludge | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 2016 | 2,732 | 7,249 | 48 | 510 | 4,224 | 48 | 1,002 | 126 | 22 | 15,961 |
| 2019 | 11,584 | 18,218 | 419 | 64 | 3,954 | 126 | 465 | 59 | 434 | 35,323 |
| 2021 | 10,623 | 15,079 | 374 | 8 | 2,943 | 237 | 863 | 29 | 8 | 30,164 |

[1]Includes agriculture and cows

[2]Includes flyash

[3]Includes commercial brush, re-route brush, xmas trees

[4]The accuracy of the waste tonnage reported is dependent on the Rockingham County Landfill customers, including private haulers, providing the attendant with the correct source of their refuse.

**Table 14 – Harrisonburg Waste Summary**

Annual rainfall in Harrisonburg in the 35 - 40 inches range which led to selecting "*Moderate*" moisture for the ClearPath Landfill Model. Landfill gas is flared from this landfill so "*Typical*" was chosen for Landfill Collection Scenario in the model.

The ClearPath waste calculator has recently been updated to better align with advancements to the EPA Waste Reduction Model (WARM). This calculation method estimates all future methane emissions from the fraction of the organic (carbon-based) mass sent to landfill and attributes them all to the current Inventory Year. The calculation uses a Waste Characterization Factor Set and methane emission factors from EPA's WARM model, version 14, with equation 1 to estimate total methane landfill emissions.[15] This calculator differs from WARM slightly by using a simplified calculation for oxidation of methane passing through soil on top of the landfill. WARM uses an oxidation factor of 10 - 30%, depending on the stage of the life of the landfill. For simplicity, this calculator uses a constant 10% oxidation rate, resulting in a slightly higher emissions estimate. Each material in the Waste Factor set produces a certain amount of methane emissions per ton of waste material over its lifetime in the landfill.

$$\text{Methane Emissions} = \text{Waste Tonnage} \times (1 - X_{ox}) \times \Sigma(\%_m \times EF_m \times (1 - LFG_m)) \qquad (\textit{Equation 1})$$

where $X_{ox}$ is Percent Oxidation Rate (0.1),
$\%_m$ is the percent of each material type, m, in the landfill waste stream,
$EF_m$ is the lifetime methane emissions factor for each material type, m, and
LFG is the lifetime landfill gas capture percentage for each material type, m

### 3g. Biogas from Waste Water Treatment

Biogas is generated by various processes in the Harrisonburg Rockingham Regional Sewer Authority (HRRSA). The biogas has a composition of approximately 67% methane ($CH_4$) and 33% carbon dioxide ($CO_2$). Prior to 2019, biogas was combusted (flared) in a waste gas burner to convert the methane which is a much stronger GHG than carbon dioxide. This combustion process is estimated to be 98% efficient at methane conversion. Starting in 2019, some of the biogas was used to heat the HRRSA biosolids dryer and anaerobic digesters. The volumes of biogas are provided in Table 15. Note that data for 2016 and 2019 were for the fiscal year, but 2021 data was obtained for the calendar year to match most of the other data in this report. The City of Harrisonburg contributes approximately half of the water to the waste water treatment facility (WWTF) so the biogas was attributed to the City based on the percentage in both the Municipal and Community inventories. This analysis estimates emissions from the combustion of Digester Gas according to the ICLEI US Community Protocol Appendix F: *Wastewater and Water Emission Activities and Sources methods WW.1.a* for $CH_4$, WW.2.a for $N_2O$ and WW.3 for biogenic $CO_2$.

| Year | Biogas Flared (cubic feet) | Biogas Use in Biosolids Dryer (cubic feet) | % Attributed to Harrisonburg City |
|---|---|---|---|
| 2016 | 67,673,385 | 0 | 53% |
| 2019 | 67,673,385 | 12,121,322 | 53% |
| 2021 | 25,525,000 | 86,368,196 | 56.4% |

**Table 15 – Harrisonburg Rockingham Regional Sewer Authority (HRRSA) biogas data**

### 3h. Recycling

Community-wide recycling data was obtained from the Harrisonburg Public Works Department Year-to-Date Solid Waste Report and detailed in Table 16. This particular recycling data was not available for 2016. Note that ClearPath does not give emissions credits for recycled materials as this methodology is not considered appropriate by all GHG emissions methods. However, these estimates are useful metrics as recycling is an important community activity.

Therefore, the EPA WARM model (v.15) was used to estimate avoided emissions due to recycling.[16] The recycling amounts for the various categories in Table 16 were multiplied by the associated WARM emissions savings and summed. The emissions savings are across the life cycle due to the recycled materials being used instead of virgin materials. These absolute recycling emissions can be considered as unofficial offsets to the Community emissions.

| | Waste Amount (tons) | | Savings (tons | |
|---|---|---|---|---|
| Category | 2019 | 2021 | $CO_2$/ton waste) | WARM v15 Categories |
| Cardboard | 188.7 | 285 | 3.14 | Corrugated containers |
| Glass | 99.3 | 103.3 | 0.28 | Glass |
| Tin/Scrap | 95.7 | 49.9 | 4.39 | Mixed Metals |
| Mixed Paper | 78.2 | 82.39 | 3.55 | Mixed Paper |
| Plastic 1 | 19.8 | 26 | 1.04 | PET |
| Plastic 2 | 9.6 | 11.7 | 0.76 | HDPE |
| Plastic Bags | 7.6 | 8.8 | 0.00 | LDPE |
| Aluminum | 3.0 | 10.3 | 9.13 | Aluminum Cans |
| **Totals** | **502** | **577** | | |
| **Carbon Emissions (mt CO2)** | **1,245** | **1,420** | **EPA WARM v15 estimate** | |

**Table 16 – Harrisonburg Solid Waste Management Recycling Data**

## 4. ANALYSIS RESULTS

The ICLEI ClearPath online software was used to analyze the data detailed in the previous sections to provide estimates of the GHG emissions for Harrisonburg in 2021 and compare to previous years including the 2016 (baseline year). All greenhouse gas emissions are normalized to carbon dioxide ($CO_2$) using the IPCC 5$^{th}$ report global warming potentials (GWPs), which account for the impact of the specific chemical emissions relative to this standard reference. Total GHG emissions are therefore reported in mass units of $CO_2$ equivalent ($CO2_e$) in metric tons, which are 1.1 times heavier than US (short) tons. Analyses are shown for both the 100-yr and 20-yr GWP values.

### 4a. Municipal Greenhouse Gas Emissions

Total Municipal GHGs calculated by ClearPath using the inventory data, assumptions, and factor sets detailed above are shown in Tables 17 and 18 at the broad sector and fuel source level. Values highlighted in red in the 100-yr GWP result tables are minor updates to the analysis for 2016/2019 due to inclusion of methane leakage directly in the ClearPath analysis, a revision to the electrical grid loss in 2019, and a double-counting error. The small differences in the Sector and Source table totals are due to rounding of subtotals in the calculations. Total Municipal GHG emissions were 5.2% less in 2021 than in 2016 for the 100-yr analysis. The main difference for the 20-yr analysis are Natural Gas leakages values which roughly triple in the 20-yr analysis due to the higher GWP over this time frame. Municipal emissions are dominated by the Buildings/Facilities sector, which are 32% and 39%, respectively, for the 20-yr and 100-yr analysis. Electricity is the dominant municipal source of GHGs contributing 42% and 51% of the emissions, respectively, for the 20-yr and 100-yr analysis.

**100-yr GWP**

| Sector | ClearPath 2016 (mtons) | ClearPath 2019 (mtons) | ClearPath 2021 (mtons) | 2021 Sector (%) | 2021 - 2016 Baseline Difference (%) |
|---|---|---|---|---|---|
| Buildings/Facilities | 8,698 | 8,974 | 7,980 | 38.7% | -8.3% |
| Water & Sewer | 3,920 | 3,932 | 3,812 | 18.5% | -2.8% |
| Vehicle Fleet | 3,473 | 3,590 | 3,129 | 15.2% | -9.9% |
| Natural Gas (Methane) Leakage | 2,130 | 2,306 | 2,194 | 10.7% | 3.0% |
| Transit Fleet | 2,003 | 2,143 | 2,004 | 9.7% | 0.0% |
| Street/Traffic Lights | 1,029 | 1,041 | 947 | 4.6% | -8.0% |
| Electric Grid Loss | 479 | 567 | 531 | 2.6% | 10.9% |
| **Totals** | **21,732** | **22,553** | **20,597** | **100.0%** | **-5.2%** |

**20-yr GWP**

| Sector | ClearPath 2016 (mtons) | ClearPath 2019 (mtons) | ClearPath 2021 (mtons) | 2021 Sector (%) | 2021 - 2016 Baseline Difference (%) |
|---|---|---|---|---|---|
| Buildings/Facilities | 8745 | 9017 | 8018 | 31.6% | -8.3% |
| Natural Gas (Methane) Leakage | 6467 | 6998 | 6661 | 26.3% | 3.0% |
| Water & Sewer | 4452 | 4463 | 4038 | 15.9% | -9.3% |
| Vehicle Fleet | 3473 | 3590 | 3129 | 12.4% | -9.9% |
| Transit Fleet | 2003 | 2143 | 2004 | 7.9% | 0.0% |
| Street/Traffic Lights | 1034 | 1045 | 950 | 3.7% | -8.1% |
| Electric Grid Loss | 482 | 570 | 534 | 2.1% | 10.8% |
| **Totals** | **26,656** | **27,826** | **25,334** | **100.0%** | **-5.0%** |

**Table 17 – Harrisonburg Municipal ClearPath GHG Emissions by Sector (100-yr and 20-yr GWP)**

**100-yr GWP**

| Emissions Source | ClearPath 2016 (mtons) | ClearPath 2019 (mtons) | ClearPath 2021 (mtons) | 2021 Sector (%) | 2021 - 2016 Baseline Difference (%) |
|---|---|---|---|---|---|
| Electricity | 11,141 | 11,697 | 10,570 | 51.3% | -5.1% |
| Diesel | 3,930 | 4,115 | 3,579 | 17.4% | -8.9% |
| Natural Gas | 4,356 | 4,314 | 4,142 | 20.1% | -4.9% |
| Gasoline | 1,546 | 1,619 | 1,555 | 7.6% | 0.6% |
| Fuel Oil | 509 | 557 | 646 | 3.1% | 27.0% |
| Biogas | 252 | 253 | 109 | 0.5% | -57.0% |
| **Totals** | **21,736** | **22,556** | **20,602** | **100.0%** | **-5.2%** |

**20-yr GWP**

| Emissions Source | ClearPath 2016 (mtons) | ClearPath 2019 (mtons) | ClearPath 2021 (mtons) | 2021 Sector (%) | 2021 - 2016 Baseline Difference (%) |
|---|---|---|---|---|---|
| Electricity | 11,198 | 11,748 | 10,613 | 41.9% | -5.2% |
| Natural Gas | 8,705 | 9,018 | 8,620 | 34.0% | -1.0% |
| Diesel | 3,930 | 4,115 | 3,579 | 14.1% | -8.9% |
| Gasoline | 1,546 | 1,619 | 1,555 | 6.1% | 0.6% |
| Fuel Oil | 513 | 562 | 652 | 2.6% | 27.1% |
| Biogas | 766 | 768 | 320 | 1.3% | -58.2% |
| **Totals** | **26,659** | **27,830** | **25,339** | **100.0%** | **-5.0%** |

**Table 18 – Harrisonburg Municipal ClearPath GHG Emissions by Source (100-yr and 20-yr GWP)**

Total Municipal GHGs in the 100-yr analysis are plotted in Figures 8 and 9 for the sectors and sources. The 20-yr plots are not shown here as they are primarily different only for natural gas leakage. It is clear from these plots that Buildings and Electricity are the biggest contributors and opportunities for future GHG reductions. It is important to remember that reductions to electricity use will also lead to less natural gas leakage and GHG emissions due to the use of natural gas by Dominion to generate almost 50% of the utility electricity as seen in Table 6.

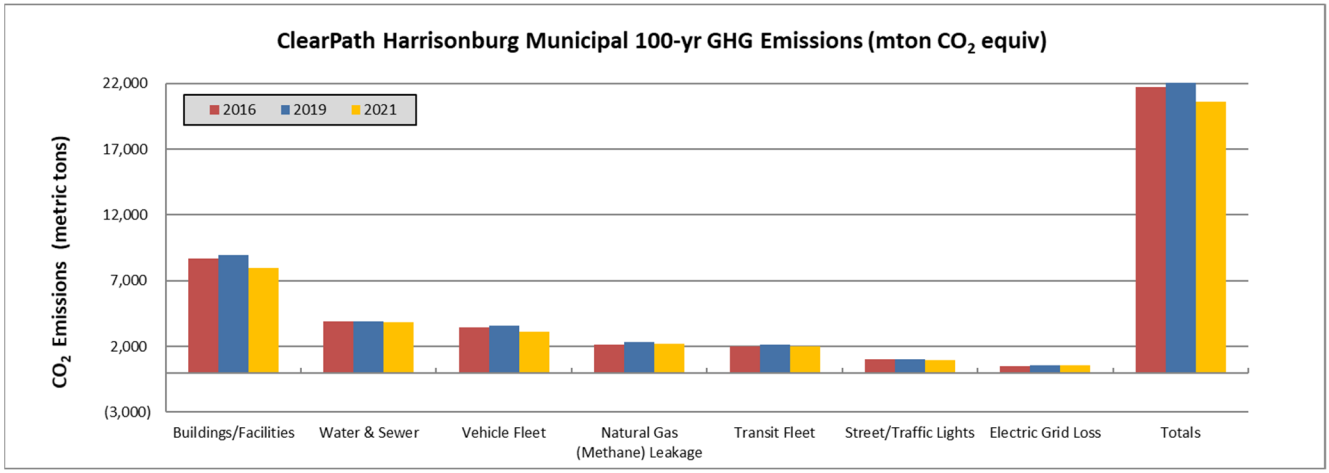


**Figure 8 – Harrisonburg Municipal 100-yr GHGs by Sector**

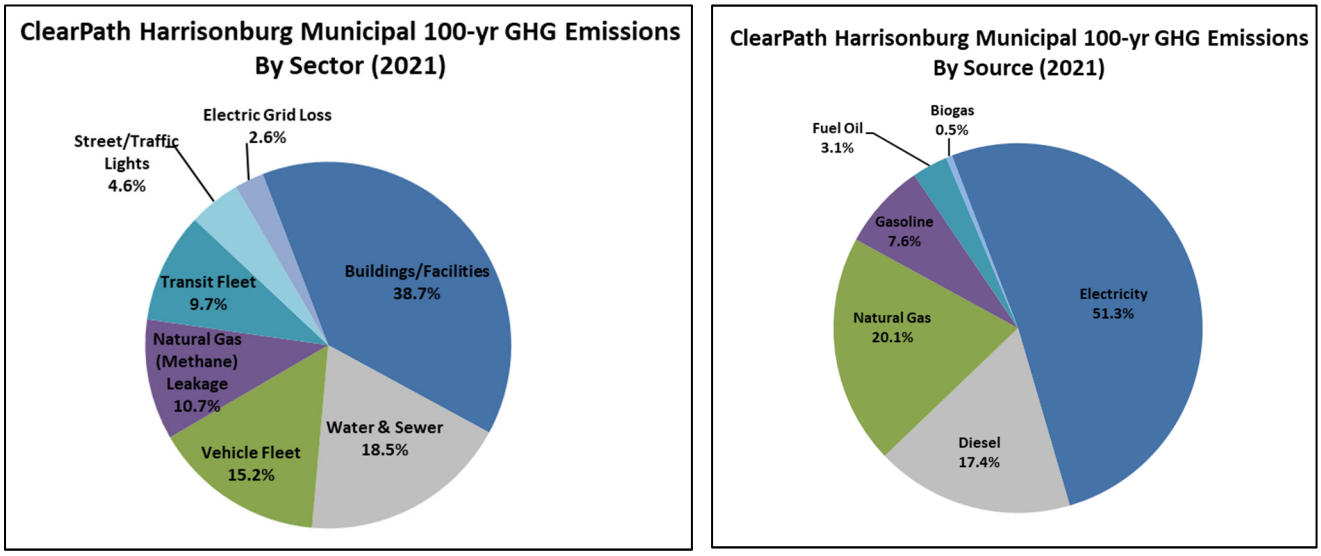


**Figure 9 – Harrisonburg Municipal 100-yr GHG emissions by Sector and Source 2021**

Table 19 provides the 100-yr GHG emissions results at a more detailed level for the category, sector and fuel source. School electricity is the largest emissions contributor at 17.5% followed by Sewer Authority electricity, diesel for City Transit Buses, and natural gas leakage from utility fuel consumption.

| | | | $CO_{2e}$ (mton) | | | 2021 | Difference |
|---|---|---|---|---|---|---|---|
| Category | Sector | Fuel Source | 2016 | 2019 | 2021 | Category (%) | 2021 vs 2016 (%) |
| SCHOOLS | Buildings/Facilities | Electricity | 3,865 | 4,308 | 3,613 | 17.5% | -6.5% |
| SEWER AUTHORITY | Water & Sewer | Electricity | 2,469 | 2,501 | 2,511 | 12.2% | 1.7% |
| CITY TRANSIT BUSES | Transit Fleet | Diesel | 1,817 | 1,926 | 1,783 | 8.7% | -1.9% |
| NATURAL GAS (METHANE) LEAKAGE | Utility | Natural Gas | 1,190 | 1,458 | 1,380 | 6.7% | 15.9% |
| WATER DEPT | Water & Sewer | Electricity | 1,199 | 1,179 | 1,192 | 5.8% | -0.5% |
| SCHOOLS | Buildings/Facilities | Natural Gas | 1,302 | 1,203 | 1,153 | 5.6% | -11.5% |
| TRAFFIC & STREET LIGHTS | Street/Traffic Lights | Electricity | 1,029 | 1,041 | 947 | 4.6% | -8.0% |
| FLEET VEHICLES | Vehicle Fleet | Gasoline | 1,106 | 1,071 | 919 | 4.5% | -17.0% |
| NATURAL GAS (METHANE) LEAKAGE | Municipality | Natural Gas | 941 | 848 | 815 | 4.0% | -13.3% |
| SCHOOL BUSES | Vehicle Fleet | Diesel | 914 | 1,006 | 688 | 3.3% | -24.8% |
| DIESEL TRUCKS | Vehicle Fleet | Diesel | 847 | 799 | 652 | 3.2% | -23.0% |
| SCHOOLS | Buildings/Facilities | Fuel Oil | 509 | 557 | 646 | 3.1% | 27.0% |
| ELECTRICAL GRID LOSS | Buildings/Facilities | Electricity | 480 | 568 | 532 | 2.6% | 10.9% |
| FIRE DEPT | Buildings/Facilities | Electricity | 551 | 609 | 531 | 2.6% | -3.6% |
| PARKS & REC DEPT | Buildings/Facilities | Electricity | 602 | 607 | 480 | 2.3% | -20.3% |
| PARKS & REC DEPT | Buildings/Facilities | Natural Gas | 464 | 376 | 388 | 1.9% | -16.4% |
| POLICE CARS | Vehicle Fleet | Gasoline | 254 | 330 | 354 | 1.7% | 39.3% |
| COMMUNITY DEVELOPMENT | Buildings/Facilities | Electricity | 269 | 264 | 249 | 1.2% | -7.3% |
| DIESEL EQUIPMENT | Vehicle Fleet | Diesel | 352 | 384 | 247 | 1.2% | -29.8% |
| TRANSPORTATION DEPT | Buildings/Facilities | Electricity | 370 | 305 | 234 | 1.1% | -36.7% |
| PARATRANSIT BUSES | Transit Fleet | Gasoline | 186 | 218 | 222 | 1.1% | 19.2% |
| DIESEL FIRE/AMBULANCE | Transit Fleet | Diesel | w/ diesel trucks | | 210 | 1.0% | |
| FIRE DEPT | Buildings/Facilities | Natural Gas | 168 | 203 | 167 | 0.8% | -0.4% |
| PUBLIC WORKS | Buildings/Facilities | Electricity | 128 | 74 | 128 | 0.6% | 0.2% |
| SEWER AUTHORITY | Water & Sewer | Biogas | 252 | 252 | 101 | 0.5% | -59.9% |
| TRANSPORTATION DEPT | Buildings/Facilities | Natural Gas | 134 | 82 | 83 | 0.4% | -37.8% |
| PUBLIC WORKS | Buildings/Facilities | Natural Gas | 93 | 87 | 82 | 0.4% | -12.3% |
| PARKING SERVICES | Buildings/Facilities | Electricity | 90 | 3 | 71 | 0.3% | -20.5% |
| EMERGENCY COMM CENTER (HRECC) | Buildings/Facilities | Electricity | 64 | 82 | 65 | 0.3% | 0.5% |
| FLEET GASOLINE EQUIPMENT | Transit Fleet | | w/ gasoline fleet | | 61 | 0.3% | |
| MISCELLANEOUS MUNICIPAL | Buildings/Facilities | Natural Gas | | | 56 | 0.3% | |
| WATER DEPT | Buildings/Facilities | Natural Gas | 21 | 19 | 18 | 0.1% | -12.6% |
| CENTRAL STORES | Buildings/Facilities | Electricity | 22 | 16 | 11 | 0.1% | -48.1% |
| SEWER AUTHORITY | Water & Sewer | Biogas | 0 | 1 | 7 | 0.0% | |
| POLICE DEPT | Buildings/Facilities | Electricity | 2 | 140 | 3 | 0.0% | 48.1% |
| CITY HALL | Buildings/Facilities | Natural Gas | 24 | 24 | 0 | 0.0% | |
| SEWER AUTHORITY | Water & Sewer | Electricity | 0.3 | 0.4 | 0 | 0.0% | |
| TOURISM | Buildings/Facilities | Natural Gas | 19 | 15 | 0 | 0.0% | |
| | | | **21,736** | **22,556** | **20,602** | **100.0%** | **-5.2%** |

**Table 19 – Harrisonburg Municipal ClearPath Detailed 100-yr GHG Emissions by Source and Fuel**

School operations (buildings and buses) have emissions from multiple fuel sources and are also 4 of the top dozen categories as seen in Table 19. The four school energy sources of electricity, natural gas, fuel oil, and diesel fuel (school buses) contribute 30% of all Municipal emissions in 2021. Therefore, to provide more insight and detail, the School sector emissions are broken down further in Table 20. In the school category, electricity accounts for the largest contribution to GHG emissions at 59% as seen in the pie chart of Figure 10. Overall, School GHG Emissions have decreased in 2021 by approximately 7% from 2016.

| | | | CO2e (mton) | | | 2021 | Difference |
|---|---|---|---|---|---|---|---|
| **School Category/Detail** | **Sector** | **Fuel Source** | **2016** | **2019** | **2021** | **Category (%)** | **2021 vs 2016 (%)** |
| Harrisonburg High School | Buildings/Facilities | Electricity | 1,145 | 1,430 | 1,161 | 19.0% | 24.9% |
| Smithland Elementary & Skyline Middle | | | 797 | 840 | 747 | 12.2% | 5.4% |
| Thomas Harrison Middle School | | | 619 | 462 | 747 | 12.2% | -25.3% |
| Stone Spring Elementary School | | | 383 | 438 | 341 | 5.6% | 14.3% |
| Spotswood Elementary School | | | 282 | 303 | 350 | 5.7% | 7.4% |
| Keister Elementary School | | | 285 | 290 | 253 | 4.1% | 1.7% |
| Waterman Elementary School | | | 279 | 284 | 271 | 4.4% | 1.6% |
| Bluestone Elementary School | | | 0 | 184 | 259 | 4.2% | |
| School Board Office | | | 75 | 78 | 163 | 2.7% | 4.1% |
| **School Electricity Totals** | | | **3,865** | **4,308** | **3,613** | **59.2%** | **-6.5%** |
| Smithland Elementary & Skyline Middle | Buildings/Facilities | Natural Gas | 249 | 312 | 316 | 27.4% | 26.7% |
| Stone Spring Elementary School | | | 205 | 224 | 253 | 21.9% | 23.5% |
| Keister Elementary School | | | 128 | 159 | 169 | 14.6% | 31.6% |
| Thomas Harrison Middle School | | | 426 | 184 | 150 | 13.0% | -64.7% |
| Spotswood Elementary School | | | 147 | 171 | 167 | 14.5% | 13.1% |
| Waterman Elementary School | | | 112 | 116 | 114 | 9.9% | 1.6% |
| Maintenance Building | | | 26 | 30 | 28 | 2.4% | 7.0% |
| School Board Office | | | 9 | 8 | 7 | 0.6% | -20.3% |
| Elon Rhodes Early Learning Center (ELC) | | | - | - | 0 | 0.0% | |
| **School Natural Gas Totals** | | | **1,302** | **1,203** | **1,153** | **18.9%** | **-11.5%** |
| **School Bus Diesel Fuel Totals** | Vehicle Fleet | Diesel | **914** | **1,006** | **688** | **11.3%** | **10.0%** |
| Harrisonburg High School | Buildings/Facilities | Fuel Oil | 508 | 557 | 646 | 56.1% | 9.6% |
| Smithland Elementary & Skyline Middle | | | 1 | 0 | 0 | 0% | |
| **School Fuel Oil (Heating)Totals** | | | **509** | **557** | **646** | **10.6%** | **9.4%** |
| **TOTALS** | | | **6,591** | **7,074** | **6,100** | **100.0%** | **-7.4%** |

**Table 20 –Harrisonburg School Detailed 100-yr GHG Emissions by Source and Fuel**

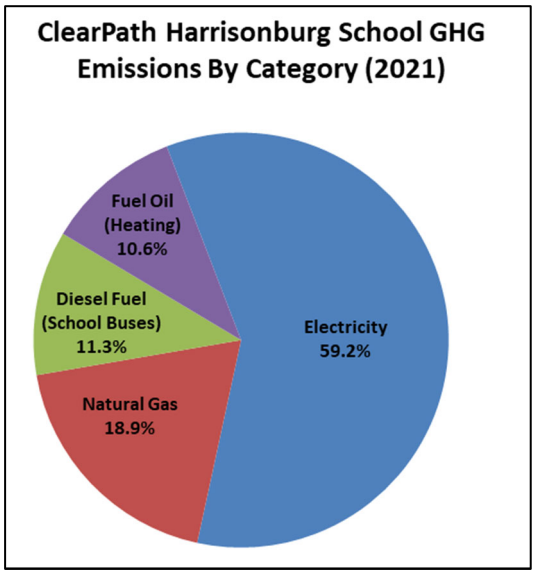


**Figure 10 – Harrisonburg School-Related 100-yr GHG emissions by Category (2021)**

## 4b. Community GHG Emissions

Community GHGs calculated by ClearPath are shown in Tables 21 and 22 and Figures 11 - 13 by sector and fuel source based on both 20-yr and 100-yr GWP values. Values shown are red in the upper 100-yr GWP table have been updated from the previous 2016/2019 analysis due to updates to the carbon emissions factors for consistency, direct inclusion of methane leakage in ClearPath, a change in the Landfill Methane Collection, and a revision to the electrical grid loss for 2019. The 20-yr GWP values in the lower table are 30% higher due to the GWP of methane which is approximately 3 times higher relative to carbon dioxide due to its shorter lifetimes in the atmosphere.

Total emissions decreased 3.4% in 2021 compared to 2016 using the 100-yr GWP values and 1.0% lower using the 20-yr values. Community emissions are dominated by the Commercial and Transportation sectors in the 100-yr analysis at around 30% of the total each. In the 20-yr analysis, Natural Gas leakage becomes the largest category. Methane leakage estimated from natural gas lines in the community and indirectly from natural gas used for electricity generation is 13% in the 100-yr analysis and 29% in the 20-yr analysis. For both analyses, the 2021 GHG totals are lower than the 2019 totals in part due to the carbon emissions factors for electricity from Dominion Power listed in Table 5.

**100-yr GWP**

| Sector | ClearPath 2016 (mtons CO2e) | ClearPath 2019 (mtons CO2e) | ClearPath 2021 (mtons CO2e) | 2016 Baseline Difference (%) | 2021 Sector (%) |
|---|---|---|---|---|---|
| Commercial | 200,943 | 206,151 | 184,274 | -8.3% | 30.3% |
| Transportation | 179,691 | 182,964 | 169,626 | -5.6% | 27.9% |
| Residential | 81,672 | 85,497 | 80,477 | -1.5% | 13.2% |
| Natural Gas Leakage | 72,359 | 79,837 | 76,487 | 5.7% | 12.6% |
| Industrial | 63,908 | 64,257 | 62,613 | -2.0% | 10.3% |
| Solid Waste | 16,914 | 23,072 | 19,703 | 16.5% | 3.2% |
| Electricity Grid Loss | 10,616 | 12,302 | 11,531 | 8.6% | 1.9% |
| Water & Wastewater | 3,920 | 3,932 | 3,813 | -2.7% | 0.6% |
| **Totals** | **630,023** | **658,012** | **608,524** | **-3.4%** | **100.0%** |

**20-yr GWP**

| Sector | ClearPath 2016 (mtons CO2e) | ClearPath 2019 (mtons CO2e) | ClearPath 2021 (mtons CO2e) | 2016 Baseline Difference (%) | 2021 Sector (%) |
|---|---|---|---|---|---|
| Natural Gas Leakage | 219,608 | 242,306 | 232,137 | 5.7% | 28.8% |
| Commercial | 201,985 | 207,130 | 185,119 | -8.4% | 23.0% |
| Transportation | 180,037 | 183,295 | 169,919 | -5.6% | 21.1% |
| Residential | 82,107 | 85,896 | 80,833 | -1.6% | 10.0% |
| Industrial | 64,136 | 64,457 | 62,788 | -2.1% | 7.8% |
| Solid Waste | 51,348 | 70,041 | 59,813 | 16.5% | 7.4% |
| Electricity Grid Loss | 10,670 | 12,356 | 11,578 | 8.5% | 1.4% |
| Water & Wastewater | 4,452 | 4,463 | 4,040 | -9.3% | 0.5% |
| **Totals** | **814,343** | **869,944** | **806,227** | **-1.0%** | **100.0%** |

**Table 21 – Harrisonburg Community ClearPath GHG Emissions by Sector for 2 Time Horizons**

**100-yr GWP**

| Emissions Source | ClearPath 2016 (mtons) | ClearPath 2019 (mtons) | ClearPath 2021 (mtons) | Baseline Difference (%) | 2021 Source (%) |
|---|---|---|---|---|---|
| Electricity | 246,549 | 253,532 | 229,106 | -7.1% | 37.6% |
| Natural Gas | 181,245 | 187,586 | 186,685 | 3.0% | 30.7% |
| Gasoline | 116,826 | 118,133 | 106,252 | -9.1% | 17.5% |
| Diesel | 62,865 | 64,832 | 63,375 | 0.8% | 10.4% |
| Solid Waste | 16,915 | 23,072 | 19,703 | 16.5% | 3.2% |
| Fuel Oil | 5,374 | 10,609 | 3,296 | -38.7% | 0.5% |
| Biogas | 252 | 253 | 110 | 0.5% | 0.02% |
| **Totals** | **630,027** | **658,016** | **608,528** | **-3.4%** | **100.0%** |

**20-yr GWP**

| Emissions Source | ClearPath 2016 (mtons) | ClearPath 2019 (mtons) | ClearPath 2021 (mtons) | Baseline Difference (%) | 2021 Source (%) |
|---|---|---|---|---|---|
| Natural Gas | 328,975 | 350,539 | 342,810 | 4.2% | 42.5% |
| Electricity | 247,801 | 254,639 | 230,042 | -7.2% | 28.5% |
| Gasoline | 117,162 | 118,452 | 106,532 | -9.1% | 13.2% |
| Diesel | 62,876 | 64,844 | 63,387 | 0.8% | 7.9% |
| Solid Waste | 51,349 | 70,041 | 59,814 | 16.5% | 7.4% |
| Fuel Oil | 5,418 | 10,665 | 3,324 | -38.7% | 0.4% |
| Biogas | 766 | 768 | 322 | -57.9% | 0.0% |
| **Totals** | **814,347** | **869,948** | **806,230** | **-1.0%** | **100.0%** |

**Table 22 – Harrisonburg Community ClearPath GHG Emissions by Source for 2 Time Horizons**

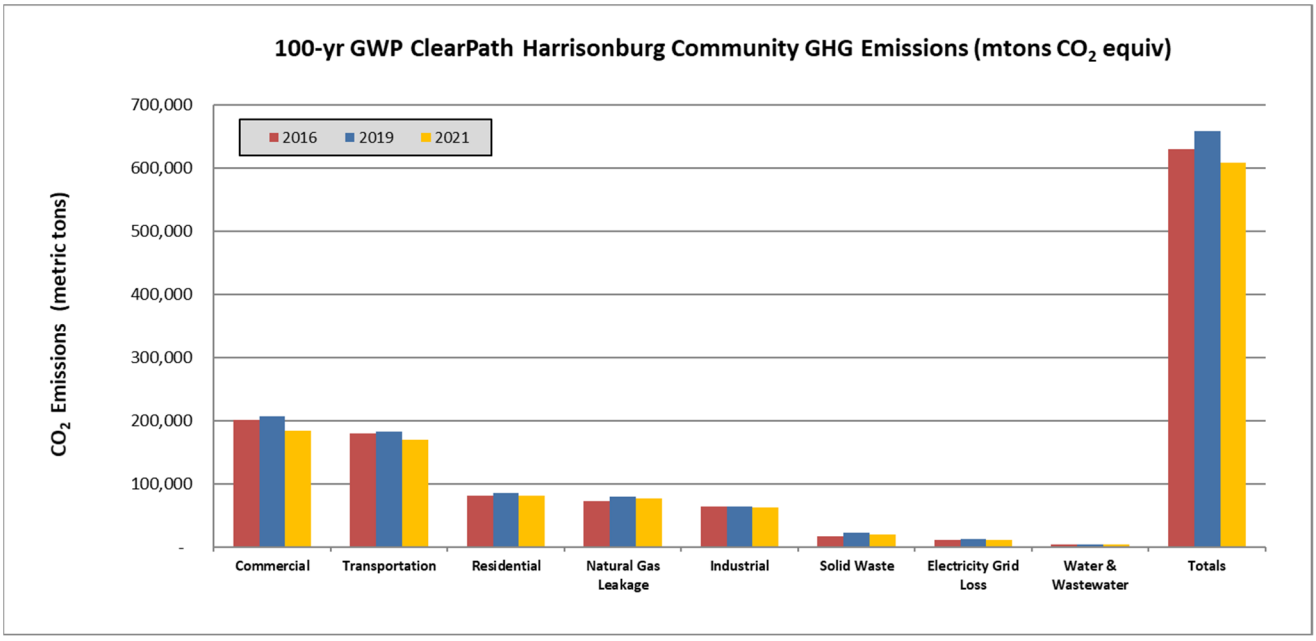


**Figure 11 – Harrisonburg Community GHGs by Sector (100-yr GWP)**

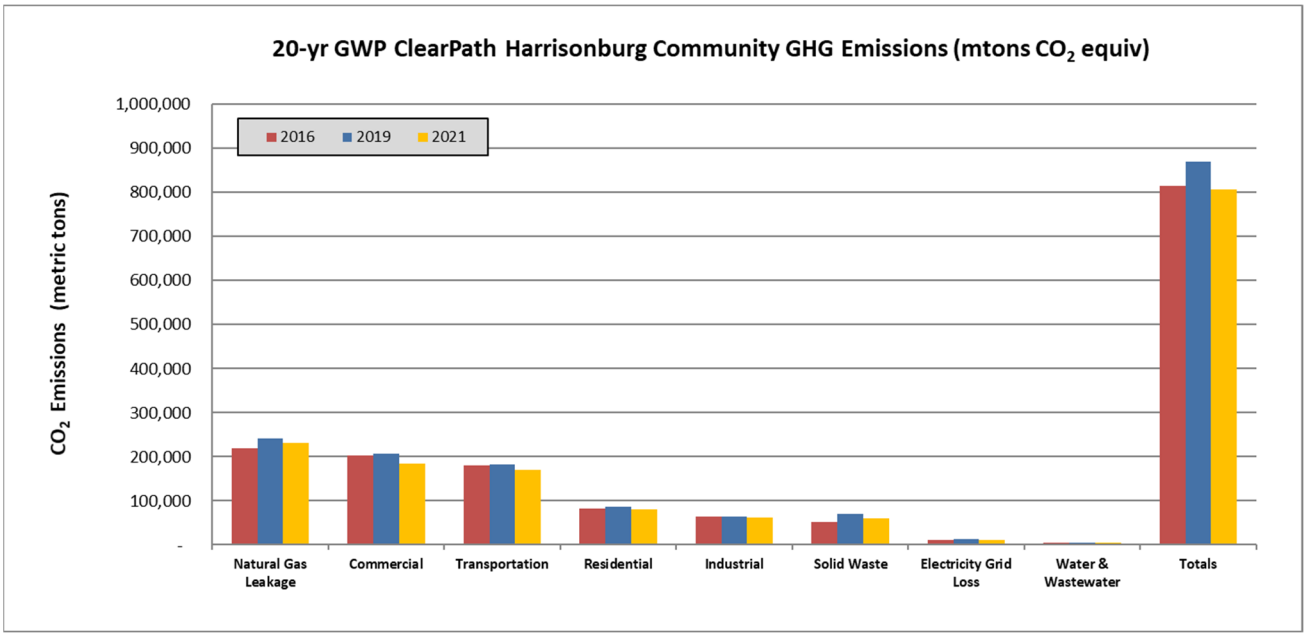


**Figure 12 – Harrisonburg Community GHGs by Sector (20-yr GWP)**

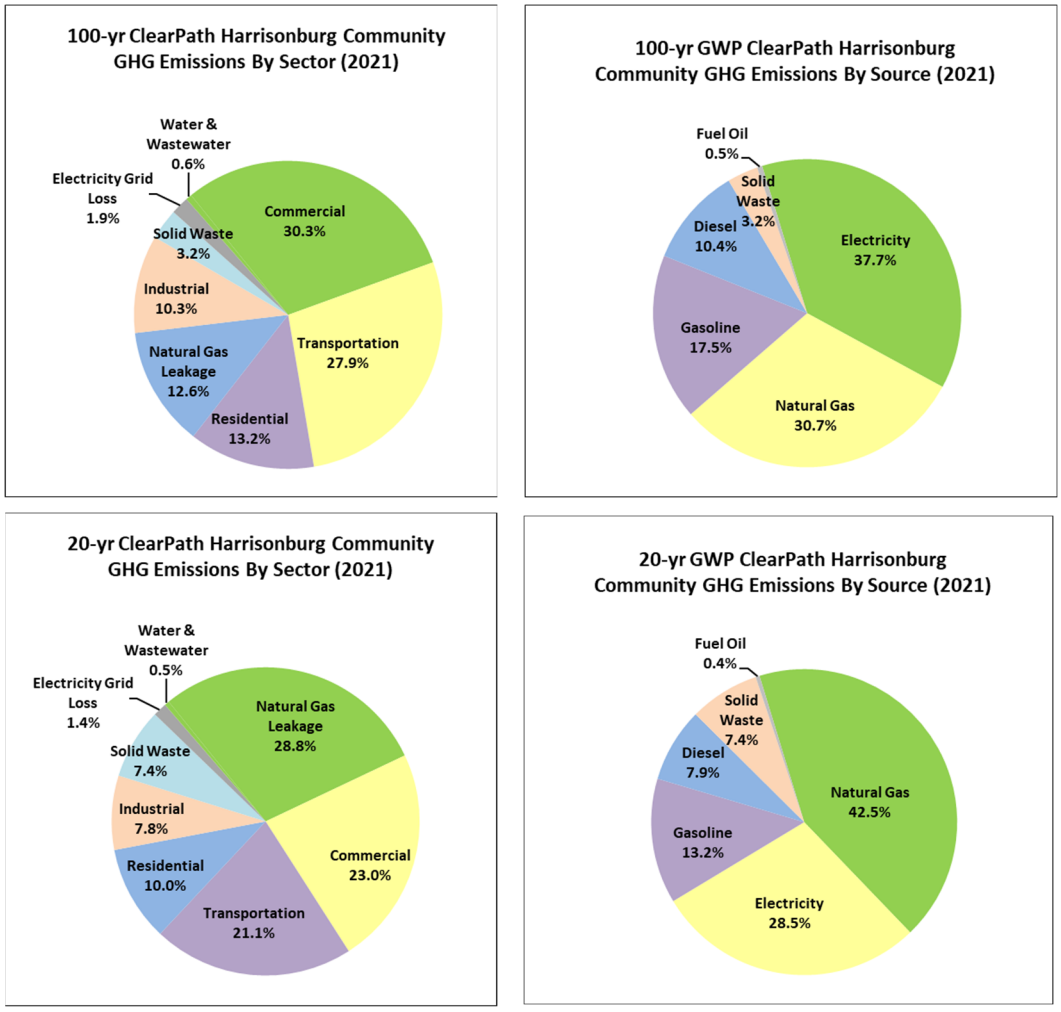


**Figure 13 – Harrisonburg Community GHG emissions by Sector and Source 2021**

Note that vehicle emissions are being overcounted slightly using this methodology. VMTs are the most reliable way to quantify Community level transportation miles, but the method depends on a vehicle and mile count so it does not differentiate electric from gasoline (or diesel) vehicles. Therefore, in this method the electric vehicle VMTs are included with associated carbon dioxide emissions. In reality, the carbon dioxide emissions for electric vehicles occur at the utility power plants rather than at the tailpipe since there is no combustion, just electricity use. So, a small number of VMTs from electric vehicles shown in Table 13 are double-counted since their carbon emissions are included in the electricity usage data and also in the VMT analysis. In the future, this analysis will account for these avoided EV tailpipe emissions, but the electric vehicle penetration is currently so low that the errors are currently insignificant. Gasoline hybrid vehicles are also more fuel efficient, but they are accounted for properly as their higher fuel economies and gasoline use are factored into the vehicle fuel economy estimates by year.

| Year | 2016 | 2019 | 2021 |
|---|---|---|---|
| Hybrid Vehicles | 288 | 530 | 716 |
| Electric Vehicles | 5 | 26 | 65 |

**Table 23 - City of Harrisonburg alternative vehicle counts**

### 4c. Recycling Carbon Emissions Savings

As mentioned above, recycling provides emissions savings since the virgin raw materials and some of the processing and transportation are not required for new products. Formally, ClearPath and most emissions protocols do not provide recycling credits for a number of technical reasons including the fact that recycling can increase simply because consumption increases. Consumption of materials other than energy and fuels is out of scope for this analysis, so it's not appropriate to give credit for the recycling due to consumption when consumption of materials is not counted.

Recycling is an important community activity, though, so these unofficial estimates are provided outside the ClearPath analysis. The emissions savings due to recycling is approximately 0.2% of the Community total, so even though 1,520 tons of recycling is a large number, the impact on emissions savings is quite small and the recycling program should not be prioritized over the much larger emissions reductions available from conservation of energy and fuels.

## 5. DISCUSSION AND CONCLUSIONS

With this GHG emissions analysis complete, the next step is to continue to set and refine goals and GHG targets using a local action plan at the Municipal and Community levels to help achieve these goals. In the last few years, GHG goals to reduce the effects of climate change have become much more aggressive as the significant impacts of this problem have become clearer. Many jurisdictions and organizations are adopting the goals of reducing GHG emissions to 50% by 2030 and achieving carbon neutrality by 2050. This range of targets and goals is aggressive, but in line with recommendations by climate scientists to avoid the worst scenarios of climate change.

Local action plans will generally include a mix of the following actions for reducing GHG emissions (in order of highest cost effectiveness and feasibility): Energy conservation, Efficiency improvements, Utility carbon intensity reduction, Renewable energy generation, Renewable energy credits (RECs) and Carbon offsets. Each of these options has different challenges, costs, and absolute amounts of emission reductions that are possible. Further quantitative analysis and modeling is recommended to provide additional metrics to complement this report and inform future local action plans and goals. These goals should depend not only on the results shown in the analysis above, but also on the preferences of the city stakeholders, technical feasibility, and cost effectiveness. It is a best practice for action plans for GHG reduction initiatives to include short, medium, and long-term goals.

Given the size and influence of JMU in the City with regard to GHG emissions, interaction and coordination with JMU staff and sustainability professionals is strongly recommended and helpful for progress in reducing GHG emissions.

Given the experience over the past analyses, community and municipal GHG emissions are recommended to be assessed yearly since the data collection and analysis is relatively straightforward. It is still recommended to try to streamline and automate some of the data compilation and analysis to simplify and shorten the analysis process.

Municipal goals and plans are somewhat easier to develop since the City is mostly in control of the buildings and operations that result in emissions. The Municipal emissions contribute approximately 3.4% of the total Community emissions in 2021 for the 100-yr GWP analysis. Programs for conservation and more efficient use of electricity will have the largest impacts and save money at the same time. Geothermal HVAC systems would increase heating and cooling efficiency for municipal projects with the appropriate space and ground characteristics. Purchasing electric vehicles as some fleet vehicles reach their replacement age will reduce emissions and save money over time. Distributed renewable generation such as solar power may be a cost-effective way to reduce GHG emissions when considered for buildings with proper orientation and roof characteristics. While solar costs have decreased significantly over the past decade, each installation must be evaluated individually for its cost effectiveness and return on investment as some sites are better suited than others for this application and costs vary significantly with the scale of the project.

Significant emissions reductions are possible for both the municipality and community with the addition of renewable energy generation by the utilities. The Virginia Clean Energy Act (VCEA) of 2020 mandates a number of actions which will reduce GHG emissions including a renewable portfolio standard (RPS) for the state's electric grid. This RPS has slightly different requirements for Appalachian Power and Dominion Energy, the largest utilities in the state. Dominion Energy – which supplies the City of Harrisonburg with electricity – is required to transition its power sources to generate 41%, 79%, and 100% of its electricity from renewable sources by 2030, 2040, and 2045 respectively.[17] As a result, Harrisonburg's 38% of GHG emissions from electricity will decline as Dominion Energy takes action, eventually becoming 0%. Continued support of the VCEA will help to not only ensure renewable sources for grid-supplied electricity in Harrisonburg, but will also ensure renewable sources for the majority of the 8.6 million Virginians. Thus, the City should strongly support the VCEA implementation and programs given the large contribution of electricity GHG emissions to its overall footprint.

A quick estimate suggests that meeting the 2030 and 2040 RPS goals will reduce electricity emission by 10% and 20%, respectively given the current Dominion electricity fuel mix of more than 50% fossil fuels and less than 7% renewables shown in Table 6. This emissions reduction estimate does not account for the increasing penetration of electric vehicles into the Transportation sector which was shown above in table 23 and expected to accelerate. Both hybrid and electric vehicles can already reduce vehicle GHG emissions by 40% per vehicle and additional gains will come battery technology and more renewably-generated electricity is added to the electrical grid. A more detailed model of the expected shifts in energy generation, product, and behavior can make more accurate predications over time and is recommend for future action plans to reduce GHG emissions.

The 20-yr analyses shown in this report highlight the significant role of methane for shorter term GHG reductions. Substitutions of renewable energy at the utility scale for natural gas for electricity will also reduce the natural gas leakage. City and natural gas utility initiatives to minimize local natural gas leaks for all sectors will reduce GHGs, save money, and minimize risks of explosions.

The largest opportunities for reductions are available at the Community level, but programs and initiatives at this level are more difficult since residents, businesses, and industries are in control of their own actions, buildings, technology, and vehicles. Again, these emissions may improve over time due to market penetration of more efficient vehicles and buildings and conservation, but this is not guaranteed especially if the economy grows. Therefore, programs to incentivize efficiency and conservation, initiated by the City or by other agencies, are recommended as the effects of climate change will be felt by everyone independent of the source of the emissions.

It should also be noted the actions taken to reduce emissions will have other important co-benefits. The conservation of energy or fuel saves money immediately with an infinite return on investment. The majority of GHG emissions are due to combustion processes that also create other forms of air pollution, which exacerbate both environmental and health effects. Other efficiency improvements due to new vehicles, heating systems, and novel technologies may have largest up from costs, but due to energy savings will have long-term return on investment (ROI).

There are many resources including check sheets, best-practice guides, and case studies available from other organizations and cities that can be leveraged in developing an action plan for Harrisonburg. The City's challenges are much the same as many other cities in the US. ICLEI has worked with hundreds of cities in the US and around the world and has complied information, reports, and examples for many best practices which can vary depending on the size, location, weather, economic, housing, and commercial characteristics of a city.

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[10]Unitrove website, Natural Gas Calculator, https://www.unitrove.com/engineering/tools/gas/natural-gas-density

[11]Energy Information Administration (EIA), Natural Gas conversion factors, https://www.eia.gov/tools/faqs/faq.php?id=45&t=8

[12]US Census Bureau Database, Physical Housing Characteristics For Occupied Housing Units, https://data.census.gov/cedsci/table?q=Harrisonburg%20city,%20Harrisonburg%20city,%20Virginia&tid=ACSST5Y2019.S2504

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[14]Virginia Department of Transportation (VDOT) Website, Traffic Data, http://www.virginiadot.org/info/ct-TrafficCounts.asp

[15]EPA Waste Reduction Model (WARM) website, https://www.epa.gov/warm/versions-waste-reduction-model-warm#WARM%20Tool%20V14)

[16]EPA Office of Resource Conservation and Recovery, Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM), Management Practices Chapters, version 15, November 2020.

[17]Virginia's Legislative Information System, 2020 Session, HB 1526 Electric utility regulation; environmental goals, https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+HB1526#

## 7. APPENDIX

### APPENDIX 1 – Harrisonburg Municipal Electricity Data

| 2021 | | | | |
|---|---|---|---|---|
| ACCOUNT | NAME | SERVICE ADDRESS | Total kWh | |
| 103748-2 | HBURG COMMUNITY DEVELOPMENT | 345 S MAIN ST | 172,480 | |
| 103748-3 | HBURG COMMUNITY DEVELOPMENT | 212 S MAIN ST | 76,196 | |
| 103748-5 | HBURG COMMUNITY DEVELOPMENT | 228 S LIBERTY ST | 13,833 | |
| 103748-6 | HBURG COMMUNITY DEVELOPMENT | 409 S MAIN ST | 519,240 | |
| 103748-8 | HBURG COMMUNITY DEVELOPMENT | 1925 E MARKET ST STE 600 | 7,651 | 789,400 |
| 103749-3 | HBURG TRANSPORTATION DEPT | 473 E WASHINGTON ST | 315,264 | |
| 103749-4 | HBURG TRANSPORTATION DEPT | 475 E WASHINGTON ST | 399,288 | |
| 103749-5 | HBURG TRANSPORTATION DEPT | 475 E WASHINGTON ST | 27,639 | 742,191 |
| 10456-2 | HBURG FIRE DEPT | 162 N LIBERTY ST | 480 | |
| 10456-3 | HBURG FIRE DEPT | 80 MARYLAND AVE SEC LIGHT | 3,195 | |
| 10456-4 | HBURG FIRE DEPT | 80 MARYLAND AVE | 234,640 | |
| 10456-5 | HBURG FIRE DEPT | 399 E MOSBY RD | 21,975 | |
| 10456-6 | HBURG FIRE DEPT | 380 PLEASANT VALLEY RD | 47,928 | |
| 10456-7 | HBURG FIRE DEPT | 210 E ROCK ST | 191,340 | |
| 10456-8 | HBURG FIRE DEPT | 101 N MAIN ST | 1,100,592 | |
| 10456-10 | HBURG FIRE DEPT | 299 LUCY DR | 58,157 | |
| 10456-13 | HBURG FIRE DEPT | 101 N MAIN ST | 24 | |
| 10456-14 | HBURG FIRE DEPT | 90 MARYLAND AVE | 6,681 | |
| 10456-15 | HBURG FIRE DEPT | 80 MARYLAND AVE TEMP METER | 16,386 | |
| 10456-17 | HBURG FIRE DEPT | 101 N MAIN ST | 698 | 1,682,096 |
| 105618-1 | HBURG PURCHASING/CENTRAL STORE | 2111 BEERY RD | 36,391 | 36,391 |
| 1306-4 | HBURG WATER DEPT | 600 VINE ST | 4,677 | |
| 1306-5 | HBURG WATER DEPT | 1241 OLD WINDMILL CIR | 20,863 | |
| 1306-6 | HBURG WATER DEPT | 1002 GREYSTONE ST | 3,604 | |
| 1306-7 | HBURG WATER DEPT | 979 SUMMIT AVE | - | |
| 1306-10 | HBURG WATER DEPT | 80 GARBERS CHURCH RD | 21,312 | |
| 1306-11 | HBURG WATER DEPT | 1751 S HIGH ST | 629 | |
| 1306-17 | HBURG WATER DEPT | 1705 PEACH GROVE AVE | 214,288 | |
| 1306-18 | HBURG WATER DEPT | 651 TOWER ST | 121,758 | |
| 1306-23 | HBURG WATER DEPT | 910 UNIVERSITY BLVD | 935 | |
| 1306-29 | HBURG WATER DEPT | 1905 E MARKET ST | 114,700 | |
| 1306-33 | HBURG WATER DEPT | 1315 W MARKET ST | 1,304 | |
| 1306-39 | HBURG WATER DEPT | 1600 SMITHLAND RD | 26,657 | |
| 1306-40 | HBURG WATER DEPT | 128 CHESTNUT RIDGE DR | 18,502 | |
| 1306-42 | HBURG WATER DEPT | 276 BLUE STONE HILLS DR | 7,512 | |
| 1306-43 | HBURG WATER DEPT | 1790 RESERVOIR ST | 166,287 | |
| 1306-44 | HBURG WATER DEPT | 1179 HARRISON ST | 184 | |
| 1306-46 | HBURG WATER DEPT | 851 PORT REPUBLIC RD | 1 | |
| 1306-47 | HBURG WATER DEPT | 2155 BEERY RD | 156,640 | |
| 1306-51 | HBURG WATER DEPT | 1111 WILLOW SPRING RD | 207 | |
| 1306-52 | HBURG WATER DEPT | 1491 OLD FURNACE RD | 20,575 | |
| 1306-53 | HBURG WATER DEPT | 250 CHESTNUT RIDGE DR | 70,174 | |
| 1306-54 | HBURG WATER DEPT | 1078 MT CLINTON PIKE | 84,346 | |
| 1306-55 | HBURG WATER DEPT | 1300 HILLCREST DR | 4,514 | |
| | RAW WATER PUMPING STATION (82% City | 82.0% | 2,508,462 | |
| | WATER TREATMENT PLANT (82% City) | 82.0% | 207,099 | 3,775,230 |

| | | | | |
|---|---|---|---|---|
| 13653-3 | HBURG CITY SCHOOLS | 100 MARYLAND AVE | **524,160** | |
| 13653-4 | HBURG CITY SCHOOLS | 100 MARYLAND AVE | **104,588** | |
| 13653-5 | HBURG CITY SCHOOLS | 100 MARYLAND AVE | **230,640** | |
| 13653-6 | HBURG CITY SCHOOLS | 1575 PEACH GROVE AVE | **987,840** | |
| 13653-7 | HBURG CITY SCHOOLS | 1575 PEACH GROVE AVE | **13,305** | |
| 13653-8 | HBURG CITY SCHOOLS | 1575 PEACH GROVE AVE | **63,260** | |
| 13653-14 | HBURG CITY SCHOOLS | 375 S CARLTON ST | **192,560** | |
| 13653-15 | HBURG CITY SCHOOLS | 375 S CARLTON ST | **535,120** | |
| 13653-16 | HBURG CITY SCHOOLS | 375 S CARLTON ST | **55,387** | |
| 13653-17 | HBURG CITY SCHOOLS | 400 MOUNTAIN VIEW DR | **16,948** | |
| 13653-19 | HBURG CITY SCHOOLS | 1311 W MARKET ST | **1,080,000** | |
| 13653-20 | HBURG CITY SCHOOLS | 451 CHICAGO AVE SEC LIGHT | **6,300** | |
| 13653-21 | HBURG CITY SCHOOLS | 451 CHICAGO AVE | **709,200** | |
| 13653-22 | HBURG CITY SCHOOLS | 451 CHICAGO AVE | **52,166** | |
| 13653-23 | HBURG CITY SCHOOLS | 451 CHICAGO AVE | **51,634** | |
| 13653-27 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **1,202,880** | |
| 13653-28 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **2,148,480** | |
| 13653-29 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **139,776** | |
| 13653-30 | HBURG CITY SCHOOLS | 1575 PEACH GROVE AVE | **44,371** | |
| 13653-33 | HBURG CITY SCHOOLS | 470 LINDA LN | **2,365,440** | |
| 13653-34 | HBURG CITY SCHOOLS | 1 COURT SQ | **214,720** | |
| 13653-35 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **31,018** | |
| 13653-36 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **40,960** | |
| 13653-37 | HBURG CITY SCHOOLS | 750 GARBERS CHURCH RD | **516,300** | |
| 13653-38 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **37,200** | |
| 13653-39 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **23,680** | |
| 13653-40 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **24,080** | |
| 13653-41 | HBURG CITY SCHOOLS | 1001 GARBERS CHURCH RD | **27,815** | **11,439,828** |
| 14133-1 | HBURG PUBLIC WORKS | 901 CHICAGO AVE | **15,156** | |
| 14133-2 | HBURG PUBLIC WORKS | 320 E MOSBY RD | **36,265** | |
| 14133-3 | HBURG PUBLIC WORKS | 320 E MOSBY RD | **113,545** | |
| 14133-4 | HBURG PUBLIC WORKS | 320 E MOSBY RD (Truck Heaters) | **23,630** | |
| 14133-5 | HBURG PUBLIC WORKS | 300 E MOSBY RD (Shop) | **120,506** | |
| 14133-7 | HBURG PUBLIC WORKS | 2055 BEERY RD (Recycle) | - | |
| 14133-13 | HBURG PUBLIC WORKS | 901 CHICAGO AVE | **19,400** | |
| 14133-19 | HBURG PUBLIC WORKS | 2115 RAMBLEWOOD RD | **20,427** | |
| 14133-26 | HBURG PUBLIC WORKS | 335 STONE SPRING RD | **432** | |
| 14133-52 | HBURG PUBLIC WORKS | 2055 BEERY RD (Trf Stn) | **52,416** | |
| 14133-55 | HBURG PUBLIC WORKS | 589 UNIVERISITY BLVD | **3,415** | |
| 14133-56 | HBURG PUBLIC WORKS | 250 RESERVOIR ST | **125** | **405,317** |
| 13653-1 | SCHOOL CROSSING LIGHT | 1583 W MARKET ST STE A (Traffic Light) | **24,123** | |
| 14133-9 | Traffic Lights | 345 S MAIN ST | **310,044** | |
| 14133-10 | Street Lights | 345 S MAIN ST | **1,445,160** | |
| 14133-11 | Street Lights - Principal Arterial | 345 S MAIN ST | **517,320** | |
| 14133-12 | Street Lights - Urban Minor Arterial | 345 S MAIN ST | **593,160** | |
| 14133-17 | Traffic Lights | 1486 W MARKET ST | **2,869** | |
| 14133-24 | Traffic Lights | 1101 E MARKET ST | **1,799** | |
| 14133-25 | Traffic Lights | 1911 S HIGH ST | **3,987** | |
| 14133-28 | Traffic Lights | 671 UNIVERSITY BLVD | **3,301** | |
| 14133-29 | Traffic Lights | 1100 S HIGH ST | **2,878** | |
| 14133-30 | Traffic Lights | 1280 GARBERS CHURCH RD | **2,132** | |
| 14133-31 | Traffic Lights | 2141 S MAIN ST | **4,390** | |
| 14133-32 | Traffic Lights | 335 STONE SPRING RD | **3,846** | |
| 14133-33 | Traffic Lights | 165 N HIGH ST | **3,067** | |
| 14133-34 | Traffic Lights | 404 VIRGINIA AVE | **3,283** | |
| 14133-36 | Traffic Lights | 1306 HILLSIDE AVE | **3,454** | |
| 14133-37 | | | | |
| 14133-38 | Traffic Lights | 2421 S MAIN ST | **3,756** | |
| 14133-39 | Traffic Lights | 1825 S MAIN ST | **5,674** | |
| 14133-40 | Street Lights | 460 PHEASANT RUN CIR | **2,727** | |
| 14133-41 | Traffic Lights | 198 S MAIN ST | **2,434** | |
| 14133-42 | Traffic Lights | 102 S MAIN ST | **2,298** | |
| 14133-43 | Traffic Lights | 28 S MAIN ST | **4,396** | |
| 14133-44 | Traffic Lights | 1575 PEACH GROVE AVE | **2,662** | |
| 14133-45 | Traffic Lights | 802 S MAIN ST | **3,981** | |
| 14133-46 | Traffic Lights | 99 BURGESS RD | **4,660** | |
| 14133-47 | Traffic Lights | 1788 RESERVOIR ST | **3,954** | |
| 14133-48 | Traffic Lights | 1915 RESERVOIR ST | **3,858** | |
| 14133-49 | Traffic Lights | 2095 RESERVOIR ST | **3,831** | |
| 14133-50 | Traffic Lights | 2396 RESERVOIR ST | **2,848** | |
| 14133-51 | Traffic Lights | 705 S MASON ST | **3,691** | |
| 14133-53 | Traffic Lights | 703 S MAIN ST | **4,291** | |
| 14133-54 | | 998 S MAIN ST | **3,863** | |
| 14133-57 | | 102 N MAIN ST | **1,684** | |
| 14133-58 | | 196 N MAIN ST | **1,991** | |
| 14133-59 | | 594 PORT REPUBLIC RD | **5,143** | |
| 14133-61 | | 901 CHICAGO AVE | **1,789** | |
| 14133-62 | | 1241 S MAIN ST | **4,499** | **2,998,843** |
| 14429-5 | HBURG POLICE DEPT | 1016 GREENDALE RD | **10,771** | |
| 14429-6 | HBURG POLICE DEPT | 1010 GREENDALE RD TEMP METER | **107** | |
| 14429-7 | HBURG POLICE DEPT | 1020 GREENDALE RD | - | **10,878** |

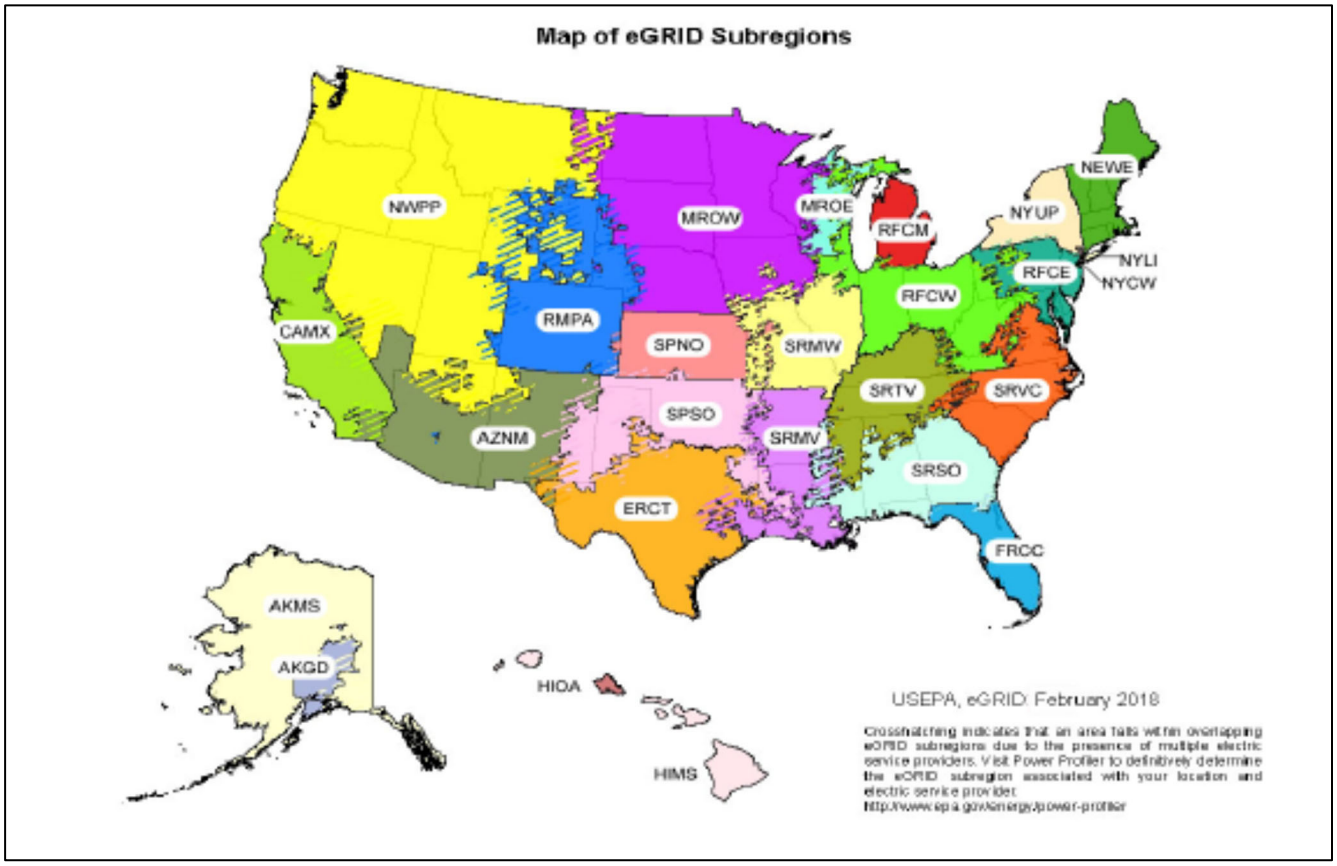
| | | | | |
|---|---|---|---|---|
| 14511-1 | DOWNTOWN PARKING SERVICES | 135 N MASON ST | 74,275 | |
| 14511-2 | DOWNTOWN PARKING SERVICES | 89 W WATER ST | 133,619 | |
| 14511-3 | DOWNTOWN PARKING SERVICES | 135 S MAIN ST SEC LIGHT | 3,180 | |
| 14511-4 | DOWNTOWN PARKING SERVICES | 282 N LIBERTY ST SEC LIGHT | 1,440 | |
| 14511-5 | DOWNTOWN PARKING SERVICES | 345 S MAIN ST SEC LIGHT | 7,680 | |
| 14511-6 | DOWNTOWN PARKING SERVICES | 44 NEWMAN AVE SEC LIGHT | 2,520 | |
| 14511-8 | DOWNTOWN PARKING SERVICES | 48 E WATER ST SEC LIGHT | 480 | |
| 14511-9 | DOWNTOWN PARKING SERVICES | 90 N MAIN ST SEC LIGHT | 2,520 | |
| 14511-11 | DOWNTOWN PARKING SERVICES | 30 W BRUCE ST | 434 | 226,148 |
| 2128-1 | HBURG RECREATION DEPT | 305 S DOGWOOD DR | - | |
| 2128-2 | HBURG RECREATION DEPT | 1583 W MARKET ST STE B | 16,736 | |
| 2128-5 | HBURG RECREATION DEPT | 100 MILLER CIR SEC LIGHT | 4,440 | |
| 2128-6 | HBURG RECREATION DEPT | 1582 S MAIN ST | 4,282 | |
| 2128-7 | HBURG RECREATION DEPT | 1582 S MAIN ST | 5,098 | |
| 2128-8 | HBURG RECREATION DEPT | 1582 S MAIN ST SEC LIGHT | 1,740 | |
| 2128-9 | HBURG RECREATION DEPT | 1545 HILLSIDE AVE SEC LIGHT | 3,840 | |
| 2128-10 | | | | |
| 2128-12 | HBURG RECREATION DEPT | 909 RESERVOIR ST | 16,730 | |
| 2128-14 | HBURG RECREATION DEPT | 620 SIMMS AVE | 15,959 | |
| 2128-15 | HBURG RECREATION DEPT | 401 E WASHINGTON ST | 4,248 | |
| 2128-16 | HBURG RECREATION DEPT | 901 CHICAGO AVE | 19,549 | |
| 2128-17 | HBURG RECREATION DEPT | 305 S DOGWOOD DR | 1,848 | |
| 2128-18 | HBURG RECREATION DEPT | 305 S DOGWOOD DR | 310,120 | |
| 2128-19 | HBURG RECREATION DEPT | 305 S DOGWOOD DR | 207,900 | |
| 2128-20 | HBURG RECREATION DEPT | 305 S DOGWOOD DR | 1,485 | |
| 2128-22 | HBURG RECREATION DEPT | 680 GARBERS CHURCH RD | 78,720 | |
| 2128-24 | HBURG RECREATION DEPT | 1582 S MAIN ST | 13,877 | |
| 2128-25 | HBURG RECREATION DEPT | 1412 SMITHLAND RD | 39,212 | |
| 2128-26 | HBURG RECREATION DEPT | 680 GARBERS CHURCH RD | 62,700 | |
| 2128-29 | HBURG RECREATION DEPT | 305 S DOGWOOD DR | - | |
| 2128-31 | HBURG RECREATION DEPT | 1583 W MARKET ST | 2,366 | |
| 2128-32 | HBURG RECREATION DEPT | 501 HILLANDALE AVE TEMP METER | - | |
| 2128-33 | HBURG RECREATION DEPT | 501 HILLANDALE AVE TEMP METER | - | |
| 2128-34 | HBURG RECREATION DEPT | 461 2ND ST | 6,209 | |
| 2128-35 | HBURG RECREATION DEPT | 1542 SMITHLAND RD | 6,642 | |
| 2128-37 | HBURG RECREATION DEPT | 1545 HILLSIDE AVE | 5,009 | |
| 2128-38 | HBURG RECREATION DEPT | 1545 HILLSIDE AVE | 2,522 | |
| 2128-39 | HBURG RECREATION DEPT | 1545 HILLSIDE AVE | 8,750 | |
| 2128-40 | HBURG RECREATION DEPT | 1545 HILLSIDE AVE | 14,500 | |
| 2128-45 | HBURG RECREATION DEPT | 501 HILLANDALE AVE | 26,720 | |
| 2128-49 | HBURG RECREATION DEPT | 177 S MAIN ST | 5,037 | |
| 2128-50 | HBURG RECREATION DEPT | 188 N LIBERTY ST | 4,500 | |
| 2128-53 | HBURG RECREATION DEPT | 1950 THOMAS BOWERS CIR | 2,281 | |
| 2128-55 | HBURG RECREATION DEPT | 431 E WASHINGTON ST TEMP METER | 2 | |
| 2128-57 | HBURG RECREATION DEPT | 431 E WASHINGTON ST SEC LIGHT | 2,400 | |
| 2128-58 | HBURG RECREATION DEPT | 620 SIMMS AVE | 569,856 | |
| 2128-61 | HBURG RECREATION DEPT | 431 E WASHINGTON ST | 4,528 | |
| 2128-62 | HBURG RECREATION DEPT | 2181 RAMBLEWOOD RD | 40,512 | |
| 2128-63 | HBURG RECREATION DEPT | 309 S DOGWOOD DR | 9,600 | |
| 2128-64 | HBURG RECREATION DEPT | 317 S MAIN ST SEC LIGHT | 480 | |
| 2128-65 | HBURG RECREATION DEPT | 246 S LIBERTY ST | 243 | |
| 2128-66 | HBURG RECREATION DEPT | 248 S LIBERTY ST | 39 | |
| 2128-67 | HBURG RECREATION DEPT | 252 S LIBERTY ST | 4 | 1,520,684 |
| 9305-1 | HBURG RHAM REG SEWER AUTH | 1321 S DOGWOOD DR | 881 | |
| HBURG RHAM REG SEWER AUTH FACILITY (56.4% City) | | 56.4% | 7,950,621 | 7,951,502 |
| 112263-1 | HRECC | 653 Tower St (Radio Tower) | 119,685 | |
| 112263-2 | HRECC | 1575 Peach Grove Ave (Radio Tower) | 41,837 | |
| 112263-5 | HRECC | 420 Mt Clinton Pike (Radio Shop) | 40,560 | |
| 112263-6 | HRECC | 424 Mt Clinton Pike (Radio Storage Sho | 2,536 | 204,618 |
| | | | 31,783,126 | 31,783,126 |

## APPENDIX 2 –EPA eGRID Regional Electricity Emission Rates (2020)

**1. Subregion Output Emission Rates (eGRID2020)**

| eGRID subregion acronym | eGRID subregion name | Total output emission rates lb/MWh | | | | | | | Non-baseload output emission rates lb/MWh | | | | | | | Grid Gross Loss (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$ | Annual $NO_X$ | Ozone Season $NO_X$ | $SO_2$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$ | Annual $NO_X$ | Ozone Season $NO_X$ | $SO_2$ | |
| AKGD | ASCC Alaska Grid | 1,097.6 | 0.100 | 0.014 | 1,104.2 | 6.0 | 5.9 | 0.6 | 1,315.1 | 0.126 | 0.017 | 1,323.4 | 6.8 | 7.0 | 0.7 | 5.5% |
| AKMS | ASCC Miscellaneous | 534.1 | 0.027 | 0.005 | 536.1 | 8.3 | 8.0 | 0.7 | 1,517.7 | 0.066 | 0.012 | 1,522.8 | 24.2 | 24.8 | 2.1 | 5.5% |
| AZNM | WECC Southwest | 846.6 | 0.054 | 0.007 | 850.2 | 0.5 | 0.5 | 0.2 | 1,368.6 | 0.090 | 0.013 | 1,374.6 | 0.8 | 0.8 | 0.2 | 5.3% |
| CAMX | WECC California | 513.5 | 0.032 | 0.004 | 515.5 | 0.5 | 0.5 | 0.0 | 1,006.5 | 0.053 | 0.007 | 1,009.9 | 0.9 | 0.9 | 0.1 | 5.3% |
| ERCT | ERCOT All | 818.6 | 0.052 | 0.007 | 822.0 | 0.5 | 0.5 | 0.5 | 1,296.6 | 0.086 | 0.012 | 1,302.3 | 0.8 | 0.7 | 0.9 | 5.2% |
| FRCC | FRCC All | 835.1 | 0.049 | 0.006 | 838.2 | 0.3 | 0.3 | 0.2 | 1,011.0 | 0.052 | 0.007 | 1,014.4 | 0.3 | 0.3 | 0.2 | 5.3% |
| HIMS | HICC Miscellaneous | 1,143.2 | 0.110 | 0.017 | 1,151.1 | 7.5 | 7.3 | 3.9 | 1,542.1 | 0.134 | 0.022 | 1,551.8 | 11.4 | 11.4 | 5.0 | 5.6% |
| HIOA | HICC Oahu | 1,653.0 | 0.178 | 0.027 | 1,665.5 | 3.8 | 3.8 | 6.8 | 1,753.5 | 0.175 | 0.027 | 1,766.0 | 4.5 | 4.5 | 7.9 | 5.6% |
| MROE | MRO East | 1,526.4 | 0.139 | 0.020 | 1,535.8 | 1.0 | 1.0 | 0.4 | 1,628.9 | 0.143 | 0.021 | 1,638.5 | 1.1 | 1.1 | 0.4 | 5.3% |
| MROW | MRO West | 979.5 | 0.104 | 0.015 | 986.6 | 0.7 | 0.8 | 0.9 | 1,810.0 | 0.185 | 0.027 | 1,822.5 | 1.3 | 1.3 | 1.6 | 5.3% |
| NEWE | NPCC New England | 528.2 | 0.074 | 0.010 | 533.0 | 0.4 | 0.4 | 0.1 | 882.5 | 0.070 | 0.009 | 886.9 | 0.4 | 0.4 | 0.1 | 5.3% |
| NWPP | WECC Northwest | 600.0 | 0.056 | 0.008 | 603.8 | 0.5 | 0.5 | 0.3 | 1,653.0 | 0.159 | 0.023 | 1,663.8 | 1.5 | 1.5 | 0.8 | 5.3% |
| NYCW | NPCC NYC/Westchester | 634.6 | 0.022 | 0.003 | 636.0 | 0.2 | 0.2 | 0.0 | 970.2 | 0.021 | 0.002 | 971.4 | 0.4 | 0.4 | 0.0 | 5.3% |
| NYLI | NPCC Long Island | 1,203.9 | 0.138 | 0.018 | 1,212.7 | 0.9 | 0.8 | 0.1 | 1,260.6 | 0.034 | 0.004 | 1,262.6 | 0.8 | 0.8 | 0.1 | 5.3% |
| NYUP | NPCC Upstate NY | 233.5 | 0.016 | 0.002 | 234.5 | 0.1 | 0.1 | 0.0 | 877.9 | 0.042 | 0.005 | 880.5 | 0.4 | 0.4 | 0.1 | 5.3% |
| PRMS | Puerto Rico Miscellaneou | 1,602.2 | 0.085 | 0.014 | 1,608.5 | 3.9 | 3.9 | 4.3 | 1,673.3 | 0.070 | 0.013 | 1,678.8 | 4.6 | 4.5 | 5.5 | 0.0% |
| RFCE | RFC East | 652.5 | 0.045 | 0.006 | 655.4 | 0.3 | 0.3 | 0.3 | 1,233.4 | 0.085 | 0.012 | 1,239.1 | 0.7 | 0.7 | 0.7 | 5.3% |
| RFCM | RFC Michigan | 1,153.1 | 0.101 | 0.014 | 1,159.8 | 0.6 | 0.7 | 0.8 | 1,725.7 | 0.163 | 0.023 | 1,736.5 | 1.1 | 1.1 | 1.6 | 5.3% |
| RFCW | RFC West | 985.0 | 0.086 | 0.012 | 990.8 | 0.6 | 0.6 | 0.7 | 1,810.4 | 0.173 | 0.025 | 1,822.2 | 1.2 | 1.1 | 1.3 | 5.3% |
| RMPA | WECC Rockies | 1,144.8 | 0.101 | 0.014 | 1,151.6 | 0.6 | 0.6 | 0.3 | 1,651.9 | 0.131 | 0.019 | 1,660.8 | 0.9 | 0.9 | 0.4 | 5.3% |
| SPNO | SPP North | 954.0 | 0.100 | 0.014 | 960.8 | 0.5 | 0.5 | 0.2 | 1,969.9 | 0.205 | 0.030 | 1,983.9 | 1.0 | 1.0 | 0.4 | 5.3% |
| SPSO | SPP South | 931.8 | 0.060 | 0.009 | 935.8 | 0.6 | 0.7 | 0.6 | 1,514.1 | 0.100 | 0.014 | 1,520.8 | 1.2 | 1.2 | 1.1 | 5.3% |
| SRMV | SERC Mississippi Valley | 740.4 | 0.032 | 0.004 | 742.4 | 0.6 | 0.7 | 0.5 | 1,137.4 | 0.055 | 0.008 | 1,141.0 | 0.9 | 1.1 | 1.0 | 5.3% |
| SRMW | SERC Midwest | 1,480.7 | 0.156 | 0.023 | 1,491.4 | 1.1 | 1.2 | 2.6 | 1,866.5 | 0.194 | 0.028 | 1,879.6 | 1.6 | 1.6 | 2.9 | 5.3% |
| SRSO | SERC South | 860.2 | 0.060 | 0.009 | 864.2 | 0.4 | 0.4 | 0.2 | 1,336.9 | 0.094 | 0.013 | 1,343.2 | 0.7 | 0.6 | 0.3 | 5.3% |
| SRTV | SERC Tennessee Valley | 834.2 | 0.075 | 0.011 | 839.2 | 0.4 | 0.4 | 0.5 | 1,511.8 | 0.135 | 0.019 | 1,521.0 | 0.7 | 0.6 | 0.9 | 5.3% |
| SRVC | SERC Virginia/Carolina | 623.1 | 0.050 | 0.007 | 626.3 | 0.3 | 0.3 | 0.2 | 1,323.9 | 0.114 | 0.016 | 1,331.3 | 0.7 | 0.8 | 0.4 | 5.3% |
| **U.S.** | | **818.3** | **0.065** | **0.009** | **822.6** | **0.5** | **0.5** | **0.5** | **1,399.6** | **0.109** | **0.015** | **1,406.8** | **0.9** | **0.9** | **0.8** | **5.3%** |

Created: 1/27/2022



## APPENDIX 3 – ClearPath Transportation Factor Sets

(2021 factor set data not yet released)

| Category | 2016 | 2019 | 2020 |
|---|---|---|---|
| Gas Passenger Vehicle Fuel Economy (MPG) | 23.95689 | 24.37713 | 24.37713 |
| Gas Passenger Vehicle (g CH4/mi) | 0.0196 | 0.0183 | 0.0180 |
| Gas PassengerVehicle (g N2O/mi) | 0.0119 | 0.0083 | 0.0074 |
| Gas Light Truck Fuel Economy (MPG) | 17.39756 | 17.86788 | 17.86788 |
| Gas Light Truck (g CH4/mi) | 0.0223 | 0.0193 | 0.0187 |
| Gas Light Truck (g N2O/mi) | 0.0214 | 0.0148 | 0.0132 |
| Gas Heavy Truck Fuel Economy (MPG) | 5.35883 | 5.371652 | 5.377347 |
| Gas Heavy Truck (g CH4/mi) | 0.1047 | 0.0785 | 0.0719 |
| Gas Heavy Truck g N2O/mi | 0.0726 | 0.0633 | 0.0611 |
| Gas Transit Bus Fuel Economy (MPG) | 17.39756 | 17.86788 | 17.86788 |
| Gas Transit Bus (g CH4/mi) | 0.0223 | 0.0193 | 0.0187 |
| Gas Transit Bus (g N2O/mi) | 0.0214 | 0.0148 | 0.0132 |
| Gas Para Transit Bus Fuel Economy (MPG) | 17.39756 | 17.86788 | 17.86788 |
| Gas Para Transit Bus (g CH4/mi) | 0.0223 | 0.0193 | 0.0187 |
| Gas Para Transit Bus (g N2O/mi) | 0.0214 | 0.0148 | 0.0132 |
| Gas Motorcycle Fuel Economy (MPG) | 23.95689 | 24.37713 | 24.37713 |
| Gas Motorcycle (g CH4/mi) | 0.0196 | 0.0183 | 0.018 |
| Gas Motorcycle (g N2O/mi) | 0.0119 | 0.0083 | 0.0074 |

| Category | 2016 | 2019 | 2020 |
|---|---|---|---|
| Diesel Passenger Vehicle Fuel Economy (MPG) | 23.95689 | 24.37713 | 24.37713 |
| Diesel Passenger Vehicle (g CH4/mi) | 0.0005 | 0.0005 | 0.0005 |
| Diesel PassengerVehicle (g N2O/mi) | 0.001 | 0.001 | 0.001 |
| Diesel Light Truck Fuel Economy (MPG) | 17.39756 | 17.86788 | 17.86788 |
| Diesel Light Truck (g CH4/mi) | 0.001 | 0.001 | 0.001 |
| Diesel Light Truck (g N2O/mi) | 0.0015 | 0.0015 | 0.0015 |
| Diesel Heavy Truck Fuel Economy (MPG) | 6.154184 | 6.392468 | 6.478112 |
| Diesel Heavy Truck g CH4/mi | 0.0051 | 0.0051 | 0.0051 |
| Diesel Heavy Truck (g N2O/mi) | 0.0048 | 0.0048 | 0.0048 |
| Diesel Transit Bus Fuel Economy (MPG) | 17.39756 | 17.86788 | 17.86788 |
| Diesel Transit Bus (g CH4/mi) | 0.001 | 0.001 | 0.001 |
| Diesel Transit Bus (g N2O/mi) | 0.0015 | 0.0015 | 0.0015 |
| Diesel Para Transit Bus Fuel Economy (MPG) | 17.39756 | 17.86788 | 17.86788 |
| Diesel Para Transit Bus (g CH4/mi) | 0.001 | 0.001 | 0.001 |
| Diesel Para Transit Bus g N2O/mi(g N2O/mi) | 0.0015 | 0.0015 | 0.0015 |
| Diesel Motorcycle Fuel Economy (MPG) | 23.95689 | 24.37713 | 24.37713 |
| Diesel Motorcycle (g CH4/mi) | 0.0005 | 0.0005 | 0.0005 |
| Diesel Motorcycle (g N2O/mi) | 0.001 | 0.001 | 0.001 |