

2022

HARRISONBURG GHG EMISSIONS REPORT



CITY OF HARRISONBURG, VIRGINIA

ICLEI GOVERNMENT EMISSIONS INVENTORY 2022 SUMMARY REPORT

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EXECUTIVE SUMMARY

The City of Harrisonburg, Virginia, greenhouse gas (GHG) emissions inventory was completed for the calendar year 2022 at both the Municipal and Community levels and compared to the previous analysis for 2016 (baseline year), 2019, and 2021. This report is part of the City of Harrisonburg’s Environmental Action Plan (EAP).

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.

Total Municipal GHG emissions in 2022 for Harrisonburg were 20,934 metric tons, a 3.8% 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 50%. School operations including electricity, natural gas, fuel oil, and diesel fuel (school buses) contributed 31% of all Municipal GHG emissions. For the 20-yr GWP, the total municipal emissions were 25,203 metric tons, a 5.5% decrease. This higher value for GHG emissions in the 20-year timeframe is due to the higher relative GWP of methane from natural gas leakage and solid waste landfill gas.

Total Community GHG emissions in 2022 for Harrisonburg were 601,000 metric tons, a 4.6% decrease from the 2016 baseline level using the 100-yr GWP values. The Commercial and Transportation sectors accounted for 31% 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 3.5% of the total Community GHG emissions. For the 20-yr GWP analysis, total Community GHG emissions in 2022 were 775,000 metric tons, a 4.8% decrease.

1. INTRODUCTION

This report summarizes both the Municipal (City operations) and Community Greenhouse Gas (GHG) emissions for the City of Harrisonburg, VA, for the calendar year 2022. These results are compared to the previous analyses for 2016 (baseline year), 2019, and 2021.

2. METHODOLOGY, SCOPE AND ASSUMPTIONS

The ICLEI ClearPath online software analysis was used for this analysis. For the 2022 assessment, the new IPCC AR6 values for both 100-yr and 20-yr Global Warming Potentials (GWPs) are used as they are updated, include feedback mechanisms and more accurate. As seen in Table 1, the main difference in the GHG values for the 20-yr time horizon compared to 100-yr is a much stronger contribution for methane since it has a shorter lifetime in the atmosphere.

Greenhouse Gas	100-Year Time Period				20-Year Time Period			
	AR4 2007	AR5 2014	AR6 2021		AR4 2007	AR5 2014	AR6 2021	
	Feedback Not Included		Feedback Included		Feedback Not Included		Feedback Included	
CO ₂	1	1	1	1	1	1	1	1
CH ₄ fossil origin	25	28	34	29.8	72	84	86	82.5
CH ₄ non fossil origin				27.2				80.8
N ₂ O	298	265	298	273	289	264	268	273

Table 1 – Global Warming Potentials from the IPCC 6th report.

3. MUNICIPAL AND COMMUNITY INVENTORY DATA

3a. Electricity

Most of the electricity data was provided by the Harrisonburg Electric Commission (HEC). 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. Harrisonburg’s Water Treatment Plant serves more than just the City, but the City controls the operations and has decided to explicitly include all of this energy and the associated emissions. In previous years, the water electricity totals were allocated based on the fraction of City customers. Sewer electricity is still allocated by flow percentage.

A summary of all of the electricity data is provided in Table 2 and in the pie chart in Figure 1. Electricity is dominated by *Schools* with 36.4% of the total usage in 2022 and Sewer plus Water with a combined contribution of 37.5%. Overall, electricity usage increased 6.1% from the 2016 baseline. A significant increase in 2022 is allocating all of water electricity instead of the fraction of the City’s flow as in previous years which was discussed above.

DEPARTMENT/FUNCTION	2016		2019		2021		2022		Difference 2022 vs 2016 (%)
	kWh	% of Total	kWh	% of Total	kWh	% of Total	kWh	% of Total	
SCHOOLS	11,364,115	36.3%	12,584,293	38.7%	11,439,828	36.0%	12,089,655	36.4%	6.4%
SEWER AUTHORITY	7,260,657	23.2%	7,304,352	22.5%	7,951,502	25.0%	7,895,319	23.7%	8.7%
WATER DEPT, TREATMENT, & PUMPING	3,524,084	11.2%	3,442,868	10.6%	3,775,230	11.9%	4,604,045	13.8%	30.6%
TRAFFIC & STREET LIGHTS	3,026,731	9.7%	3,041,823	9.4%	2,998,843	9.4%	2,998,824	9.0%	-0.9%
RECREATION DEPT	1,770,972	5.6%	1,771,940	5.5%	1,520,684	4.8%	1,533,004	4.6%	-13.4%
FIRE DEPT	1,621,085	5.2%	1,777,509	5.5%	1,682,096	5.3%	1,650,830	5.0%	1.8%
TRANSPORTATION DEPT	1,088,028	3.5%	891,593	2.7%	742,191	2.3%	779,528	2.3%	-28.4%
COMMUNITY DEVELOPMENT*	790,385	2.5%	771,089	2.4%	789,400	2.5%	780,945	2.3%	-1.2%
PUBLIC WORKS	375,779	1.2%	410,153	1.3%	405,317	1.3%	435,132	1.3%	15.8%
PARKING SERVICES	264,139	0.8%	238,848	0.7%	226,148	0.7%	223,063	0.7%	-15.6%
EMERGENCY COMMUNICATIONS CENTER (HREC)	189,058	0.6%	217,225	0.7%	204,618	0.6%	214,345	0.6%	13.4%
CENTRAL STORES	65,086	0.2%	46,264	0.1%	36,391	0.1%	37,239	0.1%	-42.8%
POLICE DEPT	6,819	0.02%	10,014	0.03%	10,878	0.03%	8,162	0.02%	19.7%
TOTALS	31,346,938	100%	32,507,971	100%	31,783,126	100%	33,250,091	100%	6.1%
ELECTRICITY GRID LOSS (%)	4.5%		5.1%		5.3%		5.3%		
ELECTRICITY GRID LOSS Total	1,410,612		1,657,907		1,684,506		1,762,255		

Table 2 – Harrisonburg Municipal Electricity Usage by Department/Function

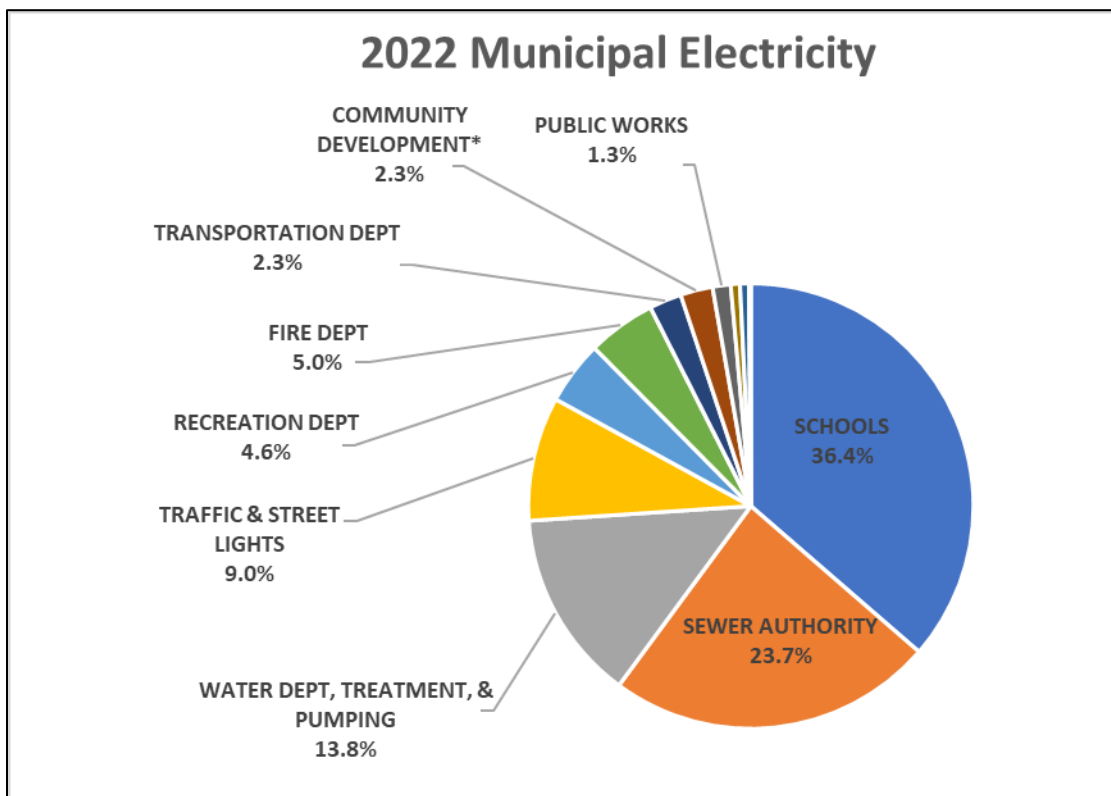


Figure 1 – Harrisonburg 2022 Municipal Electricity Pie Chart by Department/Function

As one of the largest electricity users, the Schools category for electricity usage was further broken down in Table 3 and Figure 2. Harrisonburg High School used 31% of the school system electricity in 2022. School system electricity increased approximately 6.4% from 2016 to 2021, with more than a 5.7% increase from 2021. Both Stone Spring and Keister Elementary Schools stand out with approximately a 20% increase from 2021.

School Summary			2016		2019		2021		2022		2022 (%)	Δ 2016	Δ 2021
Account	School	Address	kWh	Total	kWh	Total	kWh	Total	kWh	Total			
13653-27	Harrisonburg High School	1001 GARBERS CHURCH RD	1,324,800		1,469,760		1,202,880		1,292,160				
13653-28	Harrisonburg High School	1001 GARBERS CHURCH RD	1,826,880		2,322,240		2,148,480		2,016,960				
13653-29	Harrisonburg High School Stadium	1001 GARBERS CHURCH RD	178,944		188,544		139,776		147,072				
13653-35	Harrisonburg High School	1001 GARBERS CHURCH RD	17,161		35,931		31,018		27,550				
13653-36	Harrisonburg High School	1001 GARBERS CHURCH RD	17,920		54,160		40,960		59,920				
13653-38	Harrisonburg High School	1001 GARBERS CHURCH RD	-		54,240		37,200		36,320				
13653-39	Harrisonburg High School	1001 GARBERS CHURCH RD	-		26,960		23,680		38,000				
13653-40	Harrisonburg High School	1001 GARBERS CHURCH RD	-		24,800		24,080		26,320				
13653-41	Harrisonburg High School	1001 GARBERS CHURCH RD	-				27,815		23,198				
13653-43	Harrisonburg High School	1001 GARBERS CHURCH RD	-	3,365,705	-	4,176,635	-	3,675,889	-	3,748,200	31.0%	11.4%	2.0%
13653-33	Smithland Elementary School/Skyline Middle 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	2,374,080	2,374,080	19.6%	1.3%	0.4%
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	1,155,840	1,155,840	9.6%	-36.5%	7.0%
13653-6	Stone Spring Elementary School	1575 PEACH GROVE AVE	1,008,960		1,123,200		987,840		1,215,360				
13653-7	Stone Spring Elementary School	1575 PEACH GROVE AVE	16,290		32,443		13,305		14,892				
13653-8	Stone Spring Elementary School	1575 PEACH GROVE AVE	66,435		79,557		63,260		54,808				
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	40,942	1,326,002	11.0%	17.7%	19.6%
13653-14	Spotswood Elementary School	375 S CARLTON ST	191,760		193,000		192,560		198,200				
13653-15	Spotswood Elementary School	375 S CARLTON ST	563,520		622,560		535,120		679,200				
13653-16	Spotswood Elementary School	375 S CARLTON ST	46,257		47,627		55,387		55,008				
13653-17	Spotswood Elementary School	400 MOUNTAIN VIEW DR	27,297	828,834	21,047	884,234	16,948	800,015	36,695	969,103	8.0%	16.9%	21.1%
13653-3	Keister Elementary School	100 MARYLAND AVE	514,560		516,480		524,160		534,720				
13653-4	Keister Elementary School	100 MARYLAND AVE	101,777		93,023		104,588		100,342				
13653-5	Keister Elementary School	100 MARYLAND AVE	222,240	838,577	237,840	847,343	230,640	859,388	227,760	862,822	7.1%	2.9%	0.4%
13653-20	Waterman Elementary School	451 CHICAGO AVE SEC LIG	6,300		6,300		6,300		2,400				
13653-21	Waterman Elementary School	451 CHICAGO AVE	714,240		718,560		709,200		725,040				
13653-22	Waterman Elementary School	451 CHICAGO AVE	52,785		55,653		52,166		52,591				
13653-23	Waterman Elementary School	451 CHICAGO AVE	46,943	820,268	47,726	828,239	51,634	819,300	48,795	828,826	6.9%	1.0%	1.2%
13653-37	Bluestone Elementary School	750 GARBERS CHURCH RD	-		536,100	536,100	516,300	516,300	520,800	520,800	4.3%		0.9%
13653-34	School Board Office	1 COURT SQ	220,800	220,800	228,320	228,320	214,720	214,720	218,720	218,720	1.8%	-0.9%	1.9%
13653-42	Family Resource Center	640 S MAIN ST	-		-		-		85,262	85,262	0.7%		
Totals			11,364,115	11,364,115	12,584,293	12,584,293	11,439,828	11,439,828	12,089,655	12,089,655	100.0%	6.4%	5.7%

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

Table 3 – Harrisonburg School Electricity Usage by School

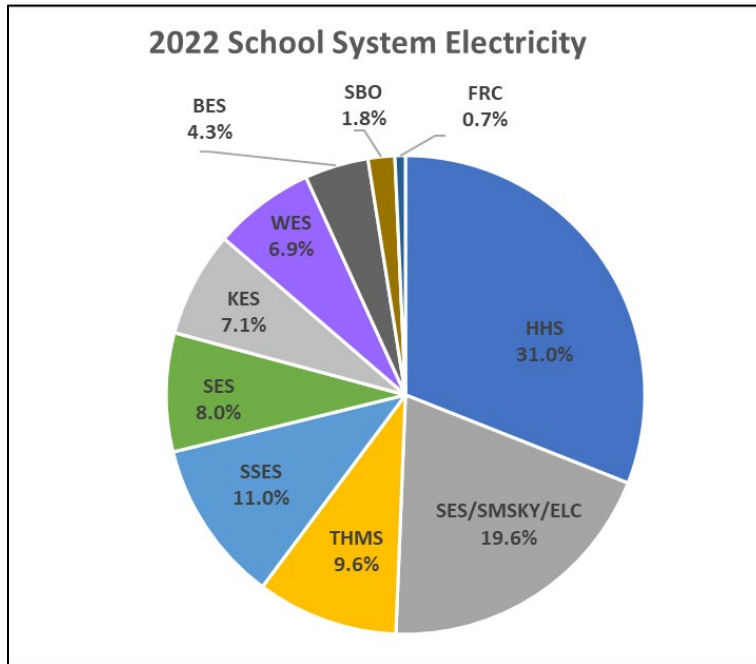


Figure 2 – Harrisonburg School Electricity Pie Chart

Community-wide electricity for Harrisonburg is shown in Table 4 and Figure 3. HPU and HRRSA electricity values were used in 2022 which is slightly different than in 2021 in which the HEC Municipal accounts were used for Water Distribution rather than the HPU values. Moreover, all Water Treatment electricity is now attributed to the City since it has control of this system and processes even though it is also supplying on the order of 18% of the water to the surrounding County.

The electricity data shows a 3.5% increase in electricity use for 2022 compared to 2016. In 2022, the Commercial sector and Residential sectors contributed 31.9% and 29.1%, respectively, while Industrial and JMU were 18.3% and 16.2% respectively.

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	4.5%	31,001,784
2022	208,840,366	228,920,377	131,097,240	20,750,727	116,098,951	12,499,364	718,207,025	4.5%	32,319,316
% Difference (2022 to 2016)	5.9%	-1.6%	11.9%	0.9%	0.6%	15.9%	3.5%	0.0%	3.5%

Table 4 – Harrisonburg Community Electricity Usage by Sector

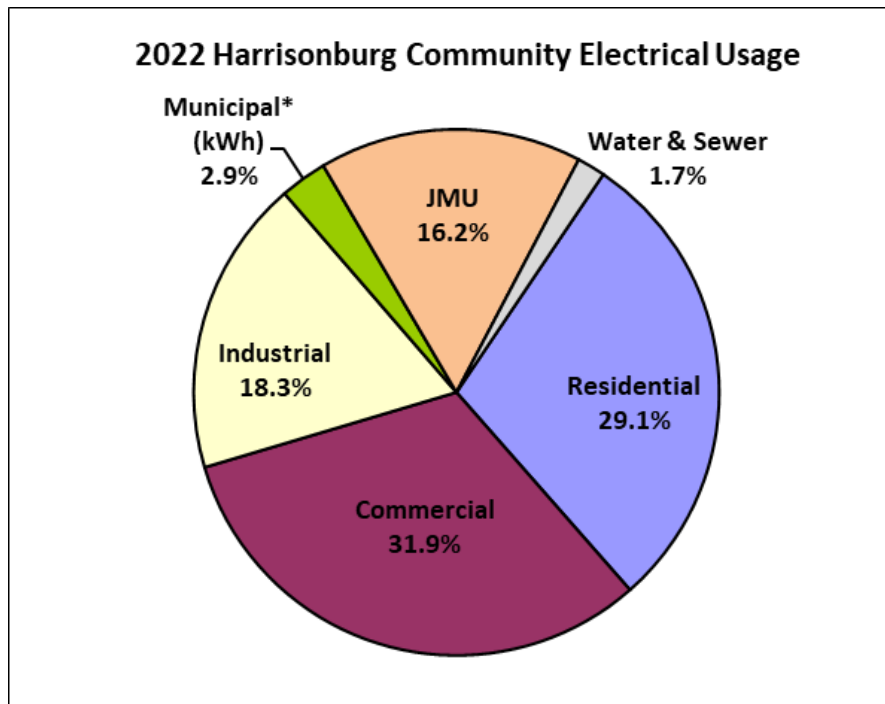


Figure 3 – Harrisonburg 2021 Community Electricity Pie Chart by Sector

Harrisonburg electricity is provided through the HEC from Dominion Energy from the generation mix they have across the regional grid. Carbon dioxide emissions factors were obtained from the Edison Electric Institute EEI database.⁴ For 2022, this EEI data came directly from Dominion Power. Methane and nitrous oxide emissions factors and grid losses come from the 2021 EPA eGrid³ database. These parameters are summarized in Table 5.

Chemical	Electricity Emission Factors (lb/MWh)			
	2016	2019	2021	2022
CO ₂	745 ⁵	751 ⁴	693 ⁴	668 ⁴
CH ₄	0.067	0.058	0.052 ³	0.052 ³
N ₂ O	0.011	0.008	0.007 ³	0.007 ³
Grid Loss (%)	4.5	5.1 ³	4.5 ³	4.5 ³

³EPA eGrid data

⁴EI Database, Edison Electric Institute (2022 directly from Dominion EEI info)

⁵Dominion Energy 2019 Sustainability and Corporate Responsibility Report

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

3b. Natural Gas

Natural gas data for 2022 is summarized in Table 7 and Figure 4. Overall, the Municipal natural gas usage decreased by 3.4% for 2022 compared to the 2016 baseline. Usage is down in all subcategories except for *Schools* which increased by almost 7%. Schools dominate natural gas usage at approximately 65% in 2022 with the Department of Parks and Recreation following at approximately 18%, the Fire Department at approximately 8%, and the rest of the categories all less than 5%. Municipal natural gas usage for categories outside of schools is reduced 18% since 2016.

Building & Address	Meter #	CY 2016		CY 2019		CY 2021		CY 2022		Difference 2022 - 2016 (%)
		Therms	% of Total	Therms	% of Total	Therms	% of Total	Therms	% of Total	
Schools - Smithland Elementary & Skyline Middle School (SMSKY)		46,896	15.5%	58,701	15.5%	60,575	16.1%	59,363	14.7%	
Schools - Stone Spring Elementary School (SSES)		38,457	11.2%	42,151	11.2%	48,409	12.9%	65,083	16.1%	
Schools - Thomas Harrison Middle School (THMS)		80,111	9.2%	34,565	9.2%	28,811	7.7%	31,105	7.7%	
Schools - Spotswood Elementary School (SES)		27,686	8.5%	32,140	8.5%	31,927	8.5%	41,238	10.2%	
Schools - Keister Elementary School (KES)		24,105	7.9%	29,830	7.9%	32,340	8.6%	31,826	7.9%	
Schools - Waterman Elementary School (WES)		21,044	5.8%	21,728	5.8%	21,785	5.8%	25,887	6.4%	
Schools - Maintenance Building		4,858	1.5%	5,563	1.5%	5,299	1.4%	5,587	1.4%	
Schools - School Board Office (SBO)		1,687	0.4%	1,485	0.4%	1,370	0.4%	1,432	0.4%	
Schools - Harrisonburg High School (HHS)		0	0.0%	0	0.0%	0	0.0%	0	0.0%	
Schools - Bluestone Elementary School (BES)		0	0.0%	0	0.0%	0	0.0%	0	0.0%	
Schools - Elon Rhodes Early Learning Center (ELC)		0	0.0%	0	0.0%	30	0.01%	192	0.05%	
Schools - High School Stadium		0	0.0%	244,843	0.0%	226,163	0.0%	230,547	0.0%	6.9%
Parks & Rec - Westover Pool - 305 S. Dogwood Dr	901118	48,620	9.3%	35,058	9.3%	40,824	10.8%	41,556	10.3%	
Parks & Rec - Lucy Simms - 620 Simms Ave	M4700071	27,996	7.0%	26,268	7.0%	22,263	5.9%	21,867	5.4%	
Parks & Rec - Community Activities Center - 305 S. Dogwood Dr	9013433	6,808	1.6%	5,982	1.6%	7,648	2.0%	5,239	1.3%	
Parks & Rec - Golf Course Maintenance 1583 W. Market St B	6112198	3,857	0.9%	3,298	0.9%	2,258	0.6%	2,032	0.5%	-19.0%
Fire Department - Public Safety Building - 101 N. Main St.	8461631	28,581	8.6%	32,459	8.6%	25,757	6.8%	24,447	6.0%	
Fire Department Station #1 80 Maryland Ave	M8600409	1,895	1.2%	4,613	1.2%	4,540	1.2%	5,400	1.3%	
Fire Department Station #1 Annex 90 Maryland Ave	U766302	1,048	0.3%	1,104	0.3%	1,098	0.3%	1,091	0.3%	-1.9%
Transportation - Central Garage - 473 E. Washington St	13600365	24,909	4.0%	15,097	4.0%	15,405	4.1%	16,196	4.0%	
Transportation - Administration Building - 475 E. Washington St	10600339	269	0.1%	282	0.1%	251	0.1%	269	0.1%	-34.6%
Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 3	6074588	4,745	1.3%	4,899	1.3%	4,306	1.1%	4,369	1.1%	
Public Works - Central Stores Warehouse - 2111 Beery Rd	M6600026	2,973	1.0%	3,833	1.0%	3,405	0.9%	2,243	0.6%	
Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 4	97800115	3,168	0.7%	2,779	0.7%	3,218	0.9%	2,999	0.7%	
Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 1	R171893	3,821	0.6%	2,451	0.6%	2,177	0.6%	1,992	0.5%	
Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 2	M7400649	1,841	0.4%	1,624	0.4%	1,313	0.3%	1,723	0.4%	
Public Works - City Shops/Traffic Signal/Eng - 320 Mosby Rd zone 5	9277707	939	0.2%	744	0.2%	919	0.2%	963	0.2%	-18.3%
General Properties - City Hall - 409 S. Main St	M7900196	4,582	1.2%	4,458	1.2%	4,234	1.1%	3,883	1.0%	-15.3%
Water Department 2155 Beery Rd	9015735	3,946	0.9%	3,482	0.9%	3,449	0.9%	3,322	0.8%	-15.8%
Tourism - Hardsesity Higgins House - 212 S. Main St	M4490516	3,598	0.8%	2,914	0.8%	2,832	0.8%	2,973	0.7%	-17.4%
Harrisonburg Water Pump House 1790 Reservoir St	3345924	207	0.0%	113	0.0%	107	0.0%	106	0.0%	-48.8%
Totals		418,646	100%	377,621	100%	376,551	100%	404,382	100%	-3.4%
Municipal Totals w/o Schools		173,803		151,458		146,004		142,670		-17.9%

Table 7 – Harrisonburg Municipal Natural Gas Usage

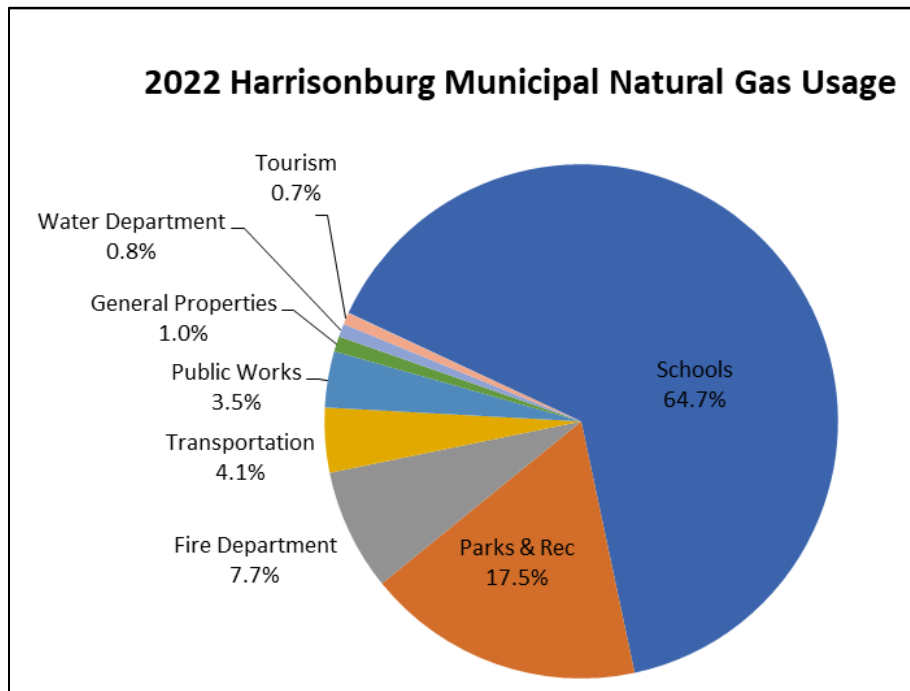


Figure 4 – Harrisonburg Municipal Natural Gas Usage 2022

The Community-wide natural gas data is summarized in Table 8 and Figure 5. It shows an overall decrease in natural gas use from 2022 compared to 2016 of 1.0%. In 2022 the Commercial sectors was the largest at nearly 40% and it includes the municipal natural gas usage detailed above, which was only 2% of the total Community-wide usage. This decrease in gas usage is despite the 11% increase in total heating degree days (HDD) compared to 2016.

Year	Residential (therms)	Commercial (therms)	JMU (therms)	Industrial (therms)	Totals (therms)	Year-to-Year Change	HDD
2016	1,733,830	6,379,270	7,837,770	4,531,220	20,482,090	---	4,922
2019	1,944,600	8,056,610	6,873,850	4,597,840	21,472,900	4.8%	4,746
2021	1,910,455	7,818,585	5,923,260	5,077,554	20,729,854	-3.5%	4,727
2022	1,853,660	8,076,744	5,915,670	4,433,741	20,279,815	-2.2%	5,468
Sector (%)	9.1%	39.8%	29.2%	21.9%	100%		
Baseline Difference	6.9%	26.6%	-24.5%	-2.2%	-1.0%	2022 vs. 2016	11.1%

Table 8 – Harrisonburg Community Natural Gas Usage

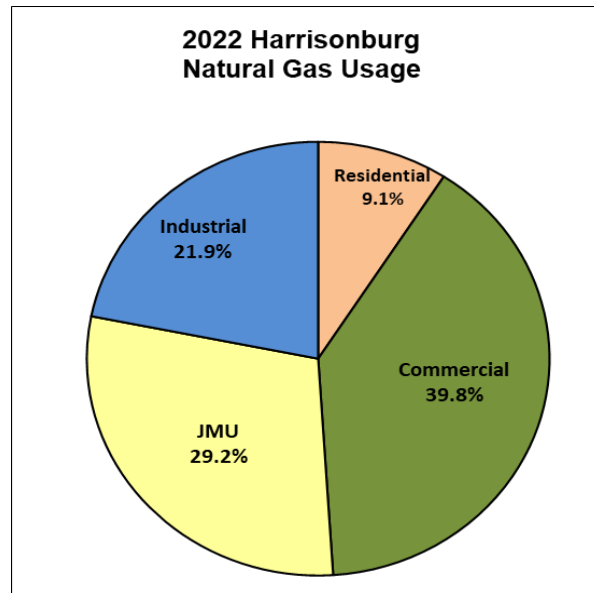


Figure 5 – Harrisonburg Community Natural Gas Usage by Sector

3c. Natural Gas Leakage

Methane emissions associated with natural gas leakage due to upstream mining, processing, and distribution are included in both the Municipal and Community-wide assessment. 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. A natural gas power plant efficiency of 44% was an adjustment from the previous value of 35% based on new EIA data.⁶ Leakage was estimated at 4% for municipal gas distribution and 2% for utility natural gas use for electricity production.

3d. Fuel Oil

Municipal use of Fuel Oil was reported for several of the City schools for heating and is detailed in Table 9.

Location	Fuel Oil Usage (gallons)				Difference 2022 – 2016 (%)
	2016	2019	2021	2022	
Harrisonburg High School (HHS)	49,462	54,222	62,911	59,624	+20.6
Smithland Elementary & Skyline Middle School (SMSKY)	79	0	0	0	-100

Table 9 – Harrisonburg Municipal Fuel Oil Usage

Community residential use of fuel oil use was estimated based on census and EIA RECs data.^{7, 8}

Year	Total Households	Households Heating w/ Fuel Oil ⁷	Average Annual Fuel Oil/Household ⁸ (Million BTU)	Average Annual Fuel Oil/Household (gallons)	Total Fuel Use (gallons)
2016	16,626	1,530	57.1	411	628,830
2019	16,723	1,121	57.1	411	460,731
2021	17,102	938	57.1	411	385,518
2022	17,102	941	52.4	377	354,757

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.

Diesel transit buses are the largest fleet contributor at 28% of the GHG emissions. Gas fleet vehicles and diesel school buses also contribute significantly at approximately 21% and 15%, respectively. There are large differences in 2022 from the 2016 baseline with some categories down significantly (gas vehicles, diesel school buses, and diesel equipment), other categories higher (gas paratransit and police gasoline, and gas equipment). Overall, the whole fleet category has 4.2% lower emissions from the baseline.

Vehicle/Equipment Fuels	2016		2019		2021		2022		2022 Count	Difference 2022 - 2016 (%)
	Gallons	%	Gallons	%	Gallons	%	Gallons	%		
Diesel Transit Buses	177,985	31.7%	188,625	32.1%	174,600	33.1%	148,820	27.6%	42	-16.4%
Gas Fleet Vehicles	121,920	21.7%	118,590	20.2%	104,625	19.8%	115,386	21.4%	263	-5.4%
Diesel School Buses	89,569	15.9%	98,518	16.8%	67,379	12.8%	83,024	15.4%	62	-7.3%
Diesel Fleet Trucks	60,231	10.7%	58,749	10.0%	63,864	12.1%	60,077	11.2%	87	-0.3%
Diesel Equipment	34,439	6.1%	37,658	6.4%	24,180	4.6%	23,839	4.4%	64	-30.8%
Gas Police Vehicles	28,939	5.1%	37,597	6.4%	40,311	7.6%	44,702	8.3%	48	54.5%
Gas ParaTransit Buses	21,208	3.8%	24,833	4.2%	25,270	4.8%	29,284	5.4%	13	38.1%
Diesel Fire Trucks/Ambulances	23,728	4.2%	19,490	3.3%	20,526	3.9%	23,837	4.4%	19	0.5%
Gas Equipment	4,070	0.7%	3,417	0.6%	6,949	1.3%	9,689	1.8%	37	138.1%
TOTALS	562,089	100%	587,477	100%	527,703	100%	538,658	100%	635	-4.2%

Table 11 – Harrisonburg Municipal Fleet Vehicle/Equipment Fuel Usage

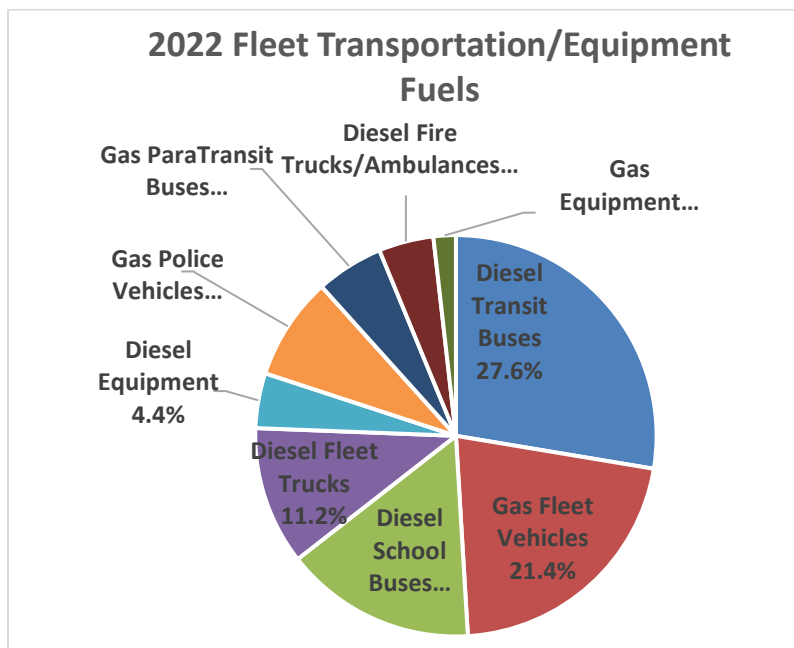


Figure 6 – Harrisonburg Vehicle/Equipment Fuel Usage

For Community-wide fuel use, the transportation sector was analyzed using Vehicle Miles Travelled (VMT) data from the Virginia Department of Transportation (VDOT) report 1220.⁹ Data for 2022 was not

published at the time of this report, but will be updated when available. The use of 2021 data as a proxy is not expected to make a huge difference in the results, but might vary by 5 – 10%.

Year	DVMT By Road Type (miles)				Annual VMT (miles)	Difference (%)
	Secondary	Primary	Interstate	Total		
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 Vehicle Miles Traveled (VMT) data for Harrisonburg.
The data for 2022 was not ready at the time of publication of this report.

Note that vehicle emissions are slightly overcounted using this methodology since VMT counts do not differentiate electric from gasoline (or diesel) vehicles. Therefore, 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.

Year	2016	2019	2021	2022
Hybrid Vehicles	288	530	716	734
Electric Vehicles	5	26	65	78

Table 13 - City of Harrisonburg alternative vehicle counts

3f. Waste Disposal

Harrisonburg City Community solid waste tonnage data is summarized for past report years in Table 15. 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.¹⁰

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
2022	10,380	16,070	362	580	67	2,213	-	973	29	30,674

¹Includes agriculture and cows
²Includes flyash
³Includes commercial brush, re-route brush, xmas trees
⁴The 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

3g. Biogas from Waste Water Treatment

Biogas is generated by various processes in the Harrisonburg Rockingham Regional Sewer Authority (HRRSA). The volumes of biogas are provided in Table 15. 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.

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%
2022	31,917,000	85,224,515	56.3%

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. Note that ClearPath does not give emissions credits for recycled materials but estimates with the EPA WARM model (v.15) as useful as unofficial offsets to the Community emissions.

Category	Waste Amount (tons)			Savings (tons CO ₂ /ton waste)	WARM v15 Categories
	2019	2021	2022		
Cardboard	188.7	285	333.4	3.14	Corrugated containers
Glass	99.3	103.3	111.4	0.28	Glass
Tin/Scrap	95.7	49.9	35.2	4.39	Mixed Metals
Mixed Paper	78.2	82.39	62.8	3.55	Mixed Paper
Plastic 1	19.8	26	27.1	1.04	PET
Plastic 2	9.6	11.7	12.1	0.76	HDPE
Plastic Bags	7.6	8.8	10.5	0.00	LDPE
Aluminum	3.0	10.3	11	9.13	Aluminum Cans
Totals	502	577	604		
Carbon Emissions (mt CO₂)	1,245	1,420	1,445	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 2022 and compare to previous years including the 2016 (baseline year) 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. Total Municipal GHG emissions were 3.8% less and 5.5% less in 2022 than in 2016 for the 100-yr and 20 -yr analyses, respectively. 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 50% of the emissions, respectively, for the 20-yr and 100-yr analysis.

<i>ClearPath Inventory by Sector Report</i>						
100-yr GWP						
Sector	ClearPath 2016 (mtons)	ClearPath 2019 (mtons)	ClearPath 2021 (mtons)	ClearPath 2022 (mtons)	2022 Sector (%)	2022 - 2016 Baseline Difference (%)
Buildings/Facilities	8,698	8,974	7,980	8132	38.8%	-2.7%
Water & Sewer	3,920	3,932	3,812	3910	18.7%	20.1%
Vehicle Fleet	3,473	3,590	3,129	3438	16.4%	-1.0%
Natural Gas (Methane) Leakage	2,130	2,306	2,194	2244	10.7%	5.1%
Transit Fleet	2,003	2,143	2,004	1776	8.5%	-12.8%
Street/Traffic Lights	1,029	1,041	947	903	4.3%	-14.0%
Electric Grid Loss	479	567	531	531	2.5%	9.8%
Totals	21,732	22,553	20,597	20,934	100.0%	-3.8%

<i>ClearPath Inventory by Sector Report</i>						
20-yr GWP						
Sector	ClearPath 2016 (mtons)	ClearPath 2019 (mtons)	ClearPath 2021 (mtons)	ClearPath 2022 (mtons)	2022 Sector (%)	2021 - 2016 Baseline Difference (%)
Buildings/Facilities	8745	9017	8018	8,169	32.4%	-6.6%
Natural Gas (Methane) Leakage	6467	6998	6661	6,211	24.6%	-4.0%
Water & Sewer	4452	4463	4038	4,169	16.5%	-6.4%
Vehicle Fleet	3473	3590	3129	3,438	13.6%	-1.0%
Transit Fleet	2003	2143	2004	1,776	7.0%	-11.3%
Street/Traffic Lights	1034	1045	950	907	3.6%	-12.3%
Electric Grid Loss	482	570	534	533	2.1%	10.6%
Totals	26,656	27,826	25,334	25,203	100.0%	-5.5%

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

<i>ClearPath Detailed Report</i>						
100-yr GWP						
Emissions Source	ClearPath 2016 (mtons)	ClearPath 2019 (mtons)	ClearPath 2021 (mtons)	ClearPath 2022 (mtons)	2021 Sector (%)	2022 - 2016 Baseline Difference (%)
Electricity	11,141	11,697	10,570	10553	50.4%	-5.3%
Diesel	3,930	4,115	3,579	3467	16.6%	-11.8%
Natural Gas	4,356	4,314	4,142	4413	21.1%	1.3%
Gasoline	1,546	1,619	1,555	1748	8.3%	13.0%
Fuel Oil	509	557	646	613	2.9%	20.4%
Biogas	252	253	109	143	0.7%	-43.2%
Totals	21,736	22,556	20,602	20,937	100.0%	-3.7%

<i>ClearPath Detailed Report</i>						
20-yr GWP						
Emissions Source	ClearPath 2016 (mtons)	ClearPath 2019 (mtons)	ClearPath 2021 (mtons)	ClearPath 2022 (mtons)	2022 Sector (%)	2021 - 2016 Baseline Difference (%)
Electricity	11,198	11,748	10,613	10,596	42.0%	-5.4%
Natural Gas	8,705	9,018	8,620	3,467	13.8%	-60.2%
Diesel	3,930	4,115	3,579	8,391	33.3%	113.5%
Gasoline	1,546	1,619	1,555	1,748	6.9%	13.0%
Fuel Oil	513	562	652	618	2.5%	20.4%
Biogas	766	768	320	387	1.5%	-49.5%
Totals	26,659	27,830	25,339	25,207	100.0%	-5.4%

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 7 and 8 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.

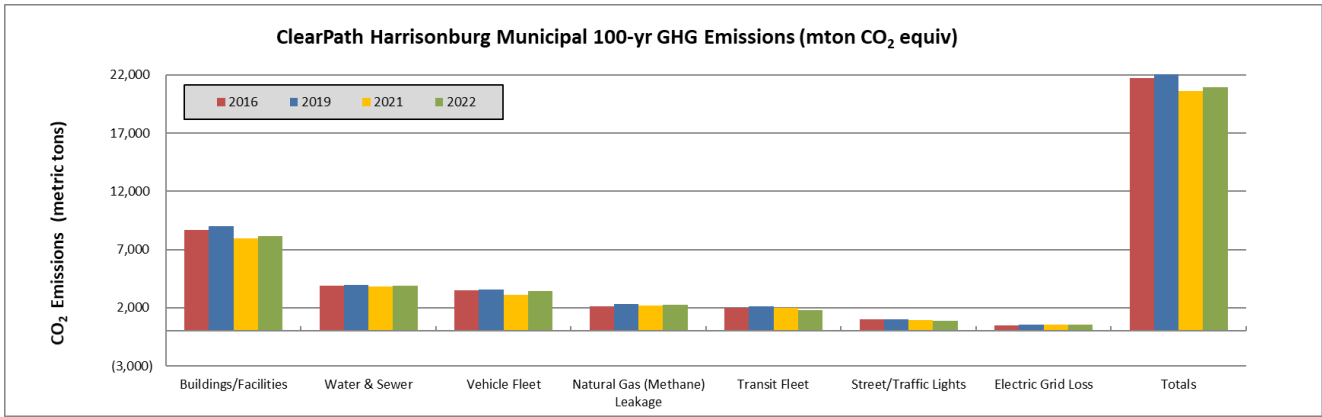


Figure 7 – Harrisonburg Municipal 100-yr GHGs by Sector

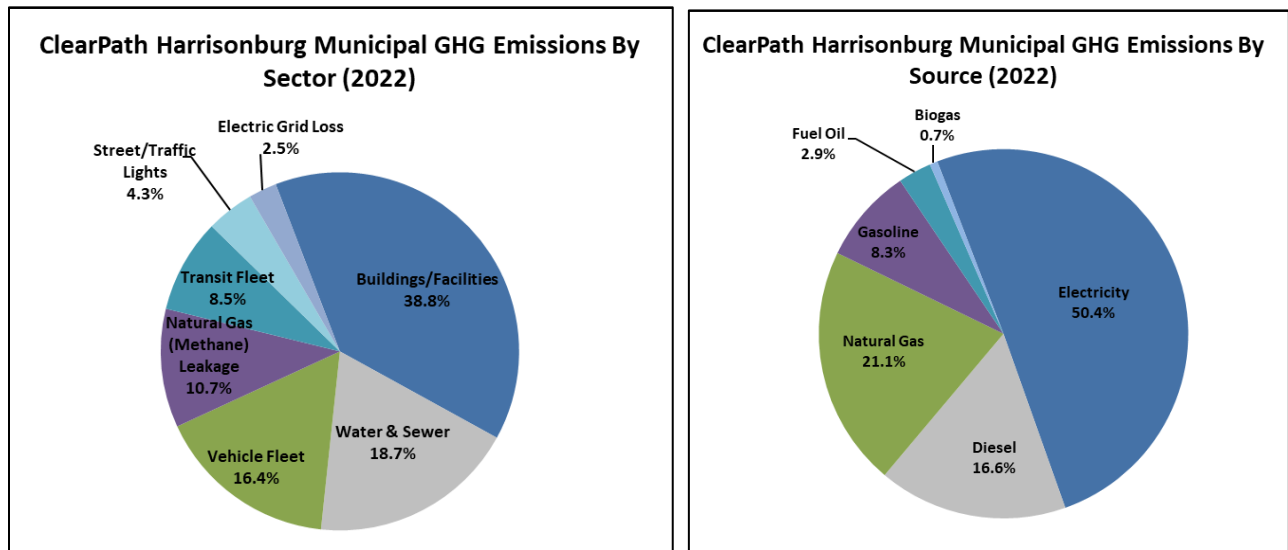


Figure 8 – Harrisonburg Municipal 100-yr GHG emissions by Sector and Source 2022

Table 19 provides the 100-yr GHG municipal emissions results at a more detailed level for the category, sector and fuel source. School electricity is the largest emissions contributor at 17.4% followed by Sewer Authority electricity, diesel for City Transit Buses, and natural gas leakage from utility fuel consumption.

School operations (buildings and buses) have emissions from multiple fuel sources and are also 4 of the top dozen categories as seen in Table 20. The four school energy sources of electricity, natural gas, fuel oil, and diesel fuel (school buses) contribute 30% of all Municipal emissions in 2022. 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 56% as seen in the pie chart of Figure 9. Overall, School GHG Emissions have decreased in 2022 by approximately 1.4% from 2016.

Category	Sector	Fuel Source	CO ₂ e (mton)				2022 Category (%)	Difference 2022 vs 2016 (%)
			2016	2019	2021	2022		
SCHOOLS	Buildings/Facilities	Electricity	3,865	4,308	3,613	3644	17.4%	-5.7%
SEWER AUTHORITY	Water & Sewer	Electricity	2,469	2,501	2,511	2,380	11.4%	-3.6%
CITY TRANSIT BUSES	Transit Fleet	Diesel	1,817	1,926	1,783	1,519	7.3%	-16.4%
NATURAL GAS (METHANE) LEAKAGE	Utility	Natural Gas	1,190	1,458	1,380	1,277	6.1%	7.3%
WATER DEPT	Water & Sewer	Electricity	1,199	1,179	1,192	1,388	6.6%	15.8%
SCHOOLS	Buildings/Facilities	Natural Gas	1,302	1,203	1,153	1392	6.6%	6.9%
TRAFFIC & STREET LIGHTS	Street/Traffic Lights	Electricity	1,029	1,041	947	904	4.3%	-12.2%
FLEET VEHICLES	Vehicle Fleet	Gasoline	1,106	1,071	919	1013	4.8%	-8.4%
NATURAL GAS (METHANE) LEAKAGE	Municipality	Natural Gas	941	848	815	967	4.6%	2.8%
SCHOOL BUSES	Vehicle Fleet	Diesel	914	1,006	688	848	4.0%	-7.3%
DIESEL TRUCKS	Vehicle Fleet	Diesel	847	799	652	613	2.9%	-27.6%
SCHOOLS	Buildings/Facilities	Fuel Oil	509	557	646	613	2.9%	20.4%
ELECTRICAL GRID LOSS	Buildings/Facilities	Electricity	480	568	532	531	2.5%	10.7%
FIRE DEPT	Buildings/Facilities	Electricity	551	609	531	498	2.4%	-9.8%
PARKS & REC DEPT	Buildings/Facilities	Electricity	602	607	480	462	2.2%	-23.3%
PARKS & REC DEPT	Buildings/Facilities	Natural Gas	464	376	388	376	1.8%	-19.0%
POLICE CARS	Vehicle Fleet	Gasoline	254	330	354	392	1.9%	54.5%
COMMUNITY DEVELOPMENT	Buildings/Facilities	Electricity	269	264	249	235	1.1%	-12.4%
DIESEL EQUIPMENT	Vehicle Fleet	Diesel	352	384	247	243	1.2%	-30.8%
TRANSPORTATION DEPT	Buildings/Facilities	Electricity	370	305	234	235	1.1%	-36.5%
PARATRANSIT BUSES	Transit Fleet	Gasoline	186	218	222	257	1.2%	38.1%
DIESEL FIRE/AMBULANCE	Transit Fleet	Diesel	w/ diesel trucks		210	243	1.2%	
FIRE DEPT	Buildings/Facilities	Natural Gas	168	203	167	165	0.8%	-1.8%
PUBLIC WORKS	Buildings/Facilities	Electricity	128	74	128	131	0.6%	2.6%
SEWER AUTHORITY	Water & Sewer	Biogas	252	252	101	135	0.6%	-46.7%
TRANSPORTATION DEPT	Buildings/Facilities	Natural Gas	134	82	83	88	0.4%	-34.6%
PUBLIC WORKS	Buildings/Facilities	Natural Gas	93	87	82	76	0.4%	-18.3%
PARKING SERVICES	Buildings/Facilities	Electricity	90	3	71	67	0.3%	-25.2%
EMERGENCY COMM CENTER (HRECC)	Buildings/Facilities	Electricity	64	82	65	65	0.3%	0.5%
FLEET GASOLINE EQUIPMENT	Transit Fleet	Gasoline	w/ gasoline fleet		61	85	0.4%	
MISCELLANEOUS MUNICIPAL	Buildings/Facilities	Natural Gas			56	55	0.3%	
WATER DEPT	Buildings/Facilities	Natural Gas	21	19	18	18	0.1%	-15.8%
CENTRAL STORES	Buildings/Facilities	Electricity	22	16	11	11	0.1%	-49.3%
SEWER AUTHORITY	Water & Sewer	Biogas	0	1	7	9	0.0%	
POLICE DEPT	Buildings/Facilities	Electricity	2	140	3	2	0.0%	6.1%
CITY HALL	Buildings/Facilities	Natural Gas	24	24				
SEWER AUTHORITY	Water & Sewer	Electricity	0.3	0.4				
TOURISM	Buildings/Facilities	Natural Gas	19	15				
			21,736	22,556	20,602	20,937	100.0%	-3.7%

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

School Category/Detail	Sector	Fuel Source	CO ₂ e (mton)				2022 Category (%)	Difference 2022 vs 2016 (%)
			2016	2019	2021	2022		
Harrisonburg High School	Buildings/Facilities	Electricity	1,145	1,430	1,161	1,130	17.4%	-1.3%
Smithland Elementary & Skyline Middle			797	840	747	716	11.0%	-10.3%
Thomas Harrison Middle School			619	462	341	348	5.4%	-43.7%
Stone Spring Elementary School			383	438	350	400	6.2%	4.3%
Spotswood Elementary School			282	303	253	292	4.5%	3.6%
Keister Elementary School			285	290	271	260	4.0%	-8.8%
Waterman Elementary School			279	284	259	250	3.8%	-10.5%
Bluestone Elementary School			0	184	163	157	2.4%	
School Board Office			75	78	68	109	1.7%	45.6%
School Electricity Totals					3,865	4,308	3,613	3,644
Smithland Elementary & Skyline Middle	Buildings/Facilities	Natural Gas	249	312	303	366	5.6%	46.7%
Stone Spring Elementary School			205	224	242	292	4.5%	42.9%
Keister Elementary School			128	159	162	195	3.0%	52.3%
Thomas Harrison Middle School			426	184	144	174	2.7%	-59.2%
Spotswood Elementary School			147	171	160	193	3.0%	30.9%
Waterman Elementary School			112	116	109	132	2.0%	17.5%
Maintenance Building			26	30	26	32	0.5%	23.9%
School Board Office			9	8	7	8	0.1%	-7.8%
Elon Rhodes Early Learning Center (ELC)			-	-	0	0	0.0%	
School Natural Gas Totals			1,302	1,203	1,153	1,392	21.4%	6.9%
School Bus Diesel Fuel Totals	Vehicle Fleet	Diesel	914	1,006	688	848	13.0%	-7.3%
Harrisonburg High School	Buildings/Facilities	Fuel Oil	508	557	646	613	44.0%	20.6%
Smithland Elementary & Skyline Middle			1	-	-	-	0%	
School Fuel Oil (Heating) Totals			509	557	646	613	9.4%	20.4%
TOTALS			6,591	7,074	6,100	6,496	100%	-1.4%

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

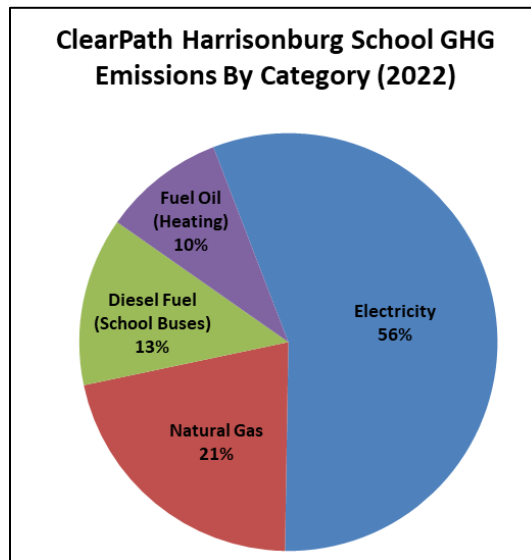


Figure 9 – Harrisonburg School-Related 100-yr GHG emissions by Category (2022)

4b. Community GHG Emissions

Community GHGs calculated by ClearPath are shown in Tables 21 and 22 and Figures 10 - 12 by sector and fuel source based on both 20-yr and 100-yr GWP values. 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 4.6% in 2022 compared to 2016 using the 100-yr GWP values and 4.8% 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 27% in the 20-yr analysis. For both analyses, the 2022 GHG totals continue to drop in part due to the lower carbon emissions factor for electricity from Dominion Power listed in Table 5.

<i>From ClearPath Inventory by Sector Report</i>		100-yr GWP				
Sector	ClearPath 2016 (mtons CO2e)	ClearPath 2019 (mtons CO2e)	ClearPath 2021 (mtons CO2e)	ClearPath 2022 (mtons CO2e)	2016 Baseline Difference (%)	2022 Sector (%)
Commercial	200,943	206,151	184,274	185,008	-7.9%	30.8%
Transportation	179,691	182,964	169,626	165,213	-8.1%	27.5%
Residential	81,672	85,497	80,477	76,450	-6.4%	12.7%
Natural Gas Leakage	72,359	79,837	76,487	76,144	5.2%	12.7%
Industrial	63,908	64,257	62,613	63,045	-1.4%	10.5%
Solid Waste	16,914	23,072	19,703	21,323	26.1%	3.5%
Electricity Grid Loss	10,616	12,302	11,531	9,740	-8.3%	1.6%
Water & Wastewater	3,920	3,932	3,813	3,910	-0.3%	0.7%
Totals	630,023	658,012	608,524	600,833	-4.6%	100.0%

<i>From ClearPath Inventory by Sector Report</i>		20-yr GWP				
Sector	ClearPath 2016 (mtons CO2e)	ClearPath 2019 (mtons CO2e)	ClearPath 2021 (mtons CO2e)	ClearPath 2022 (mtons CO2e)	2016 Baseline Difference (%)	2022 Sector (%)
Natural Gas Leakage	219,608	242,306	232,137	210,758	-4.0%	27.2%
Commercial	201,985	207,130	185,119	185,833	-8.0%	24.0%
Transportation	180,037	183,295	169,919	165,354	-8.2%	21.3%
Residential	82,107	85,896	80,833	76,786	-6.5%	9.9%
Industrial	64,136	64,457	62,788	63,231	-1.4%	8.2%
Solid Waste	51,348	70,041	59,813	59,033	15.0%	7.6%
Electricity Grid Loss	10,670	12,356	11,578	9,781	-8.3%	1.3%
Water & Wastewater	4,452	4,463	4,040	4,170	-6.3%	0.5%
Totals	814,343	869,944	806,227	774,946	-4.8%	100.0%

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

<i>From ClearPath Detailed Report</i>		100-yr GWP				
Emissions Source	ClearPath 2016 (mtons)	ClearPath 2019 (mtons)	ClearPath 2021 (mtons)	ClearPath 2022 (mtons)	Baseline Difference (%)	2022 Source (%)
Electricity	246,549	253,532	229,106	226,538	-8.1%	37.7%
Natural Gas	181,245	187,586	186,685	183,973	-43.4%	30.6%
Gasoline	116,826	118,133	106,252	102,642	57.5%	17.1%
Diesel	62,865	64,832	63,375	62,572	-0.5%	10.4%
Solid Waste	16,915	23,072	19,703	21,324	26.1%	3.5%
Fuel Oil	5,374	10,609	3,296	3,646	-32.1%	0.6%
Biogas	252	253	110	144	-43.1%	0.02%
Totals	630,027	658,016	608,528	600,838	-4.6%	100.0%

<i>From ClearPath Detailed Report</i>		20-yr GWP				
Emissions Source	ClearPath 2016 (mtons)	ClearPath 2019 (mtons)	ClearPath 2021 (mtons)	ClearPath 2022 (mtons)	Baseline Difference (%)	2022 Source (%)
Natural Gas	328,975	350,539	342,810	319,028	-3.0%	41.2%
Electricity	247,801	254,639	230,042	227,472	-8.2%	29.4%
Gasoline	117,162	118,452	106,532	102,772	-12.3%	13.3%
Diesel	62,876	64,844	63,387	62,582	-0.5%	8.1%
Solid Waste	51,349	70,041	59,814	59,034	15.0%	7.6%
Fuel Oil	5,418	10,665	3,324	3,674	-32.2%	0.5%
Biogas	766	768	322	388	-49.4%	0.1%
Totals	814,347	869,948	806,230	774,950	-4.8%	100.0%

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

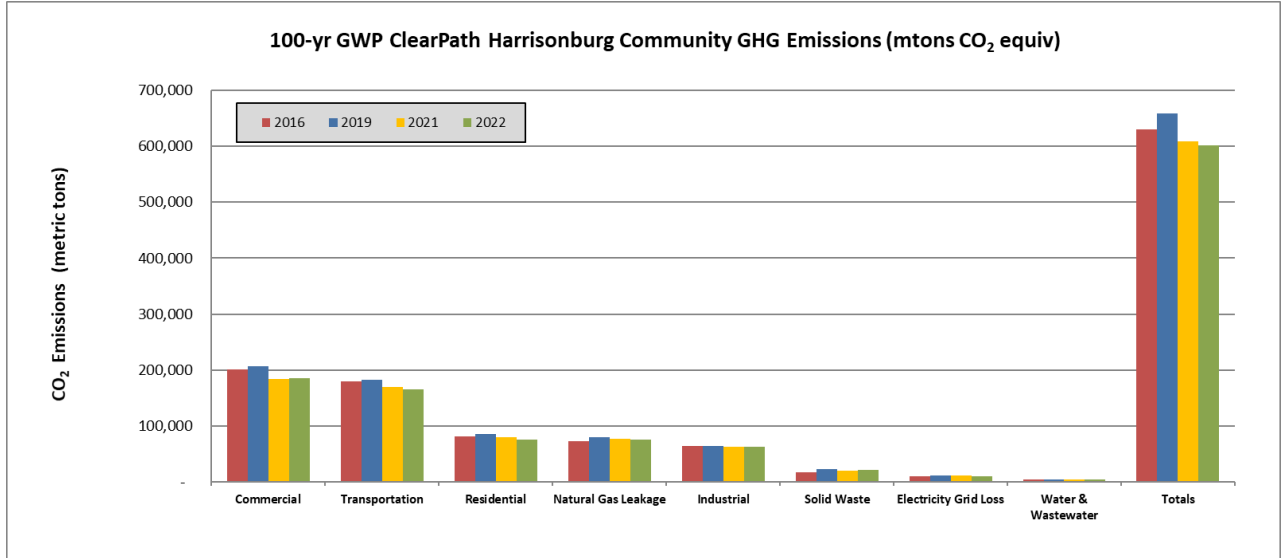


Figure 10– Harrisonburg Community GHGs by Sector (100-yr GWP)

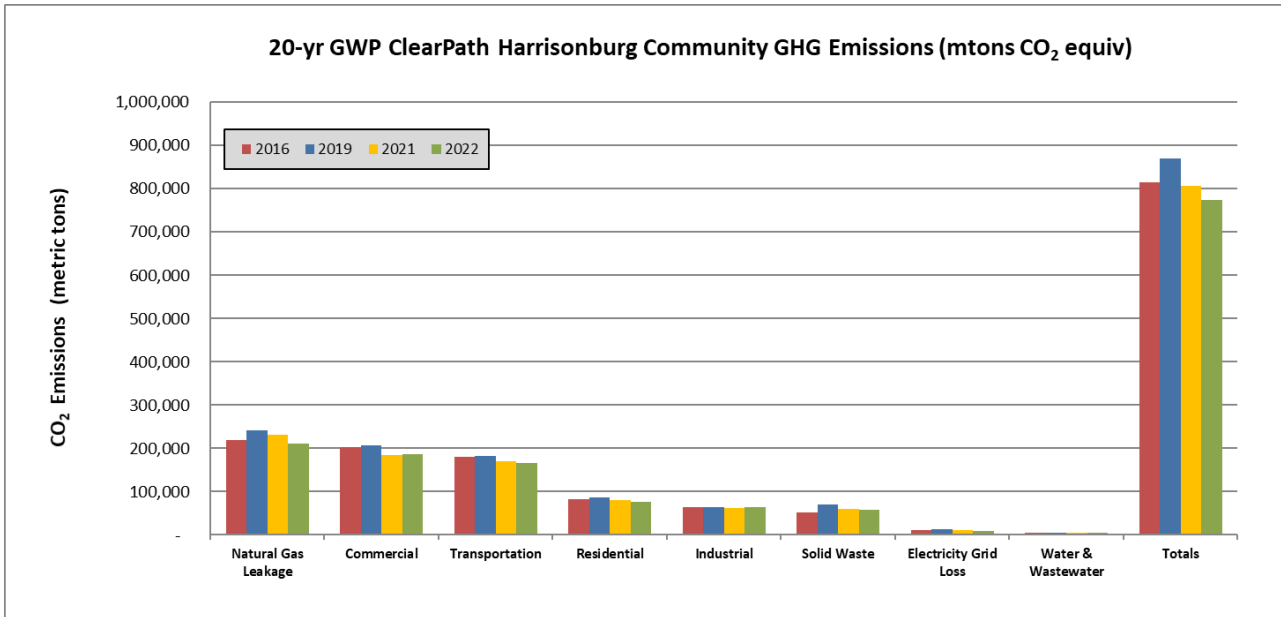


Figure 11 – Harrisonburg Community GHGs by Sector (20-yr GWP)

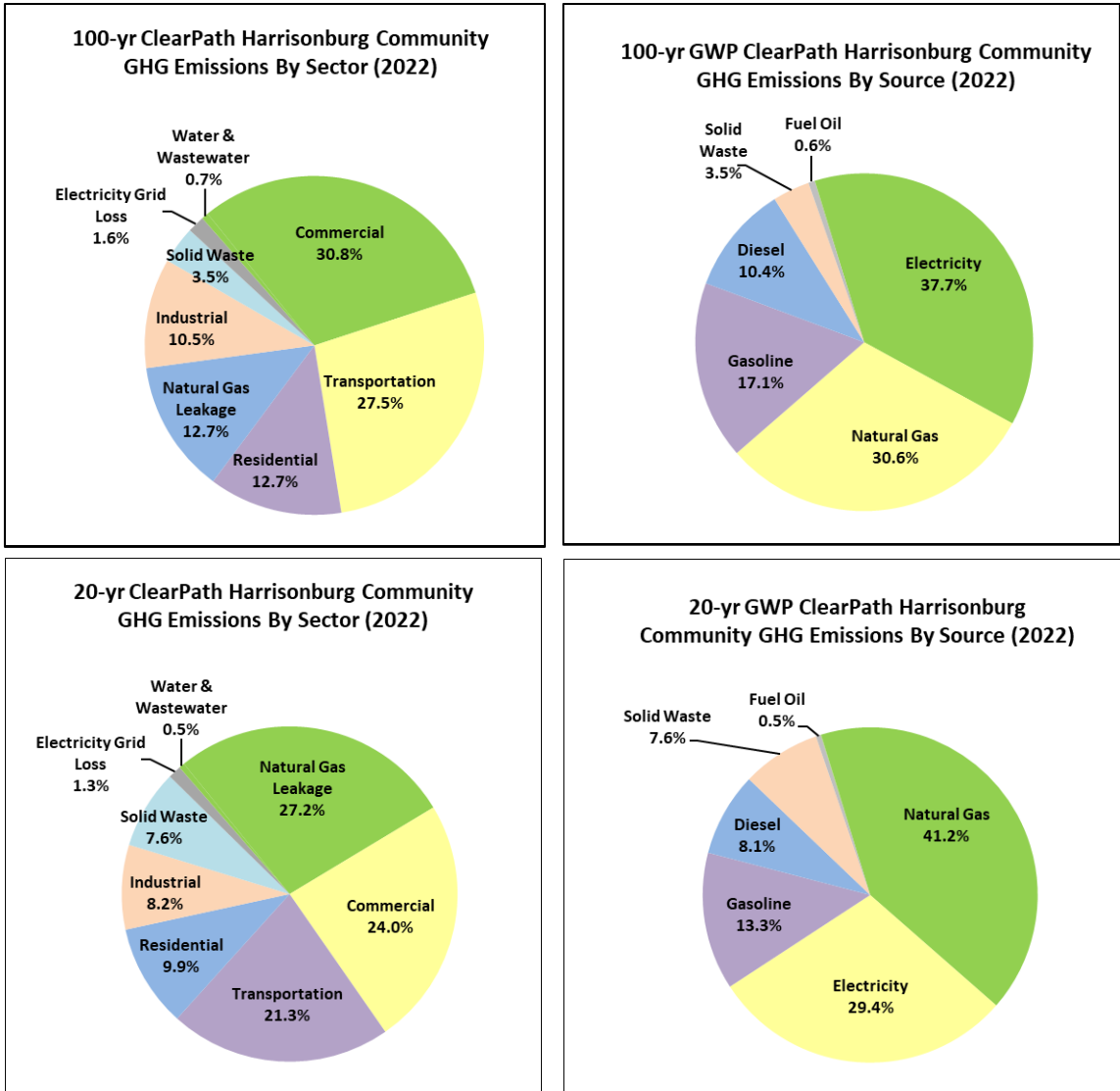


Figure 12 – Harrisonburg Community GHG emissions by Sector and Source 2022

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