GHG Inventory

Dayton Kettering MSA

December 4, 2023

Table of Contents

Disclaimer

The information in this analysis has been compiled to offer an assessment of the GHG emissions for MVRPC. Reasonable skill, care and diligence have been exercised to assess the information acquired during the preparation of this analysis, but no guarantees or warranties are made regarding the accuracy or completeness of this information. This document, the information it contains and the information and basis on which it relies, are subject to changes that are beyond the control of the author. The information provided by others is believed to be accurate but has not been verified.

1 Executive Summary

Total GHG emissions for Dayton Kettering MSA in 2021 totaled 11 MMtCO2e, with the majority of emissions coming from the residential sector (47%), followed by commercial/institutional (29%) and industrial (24%). In terms of fuels, electricity is the largest source (44%), followed by gasoline (27%) and natural gas (20%).

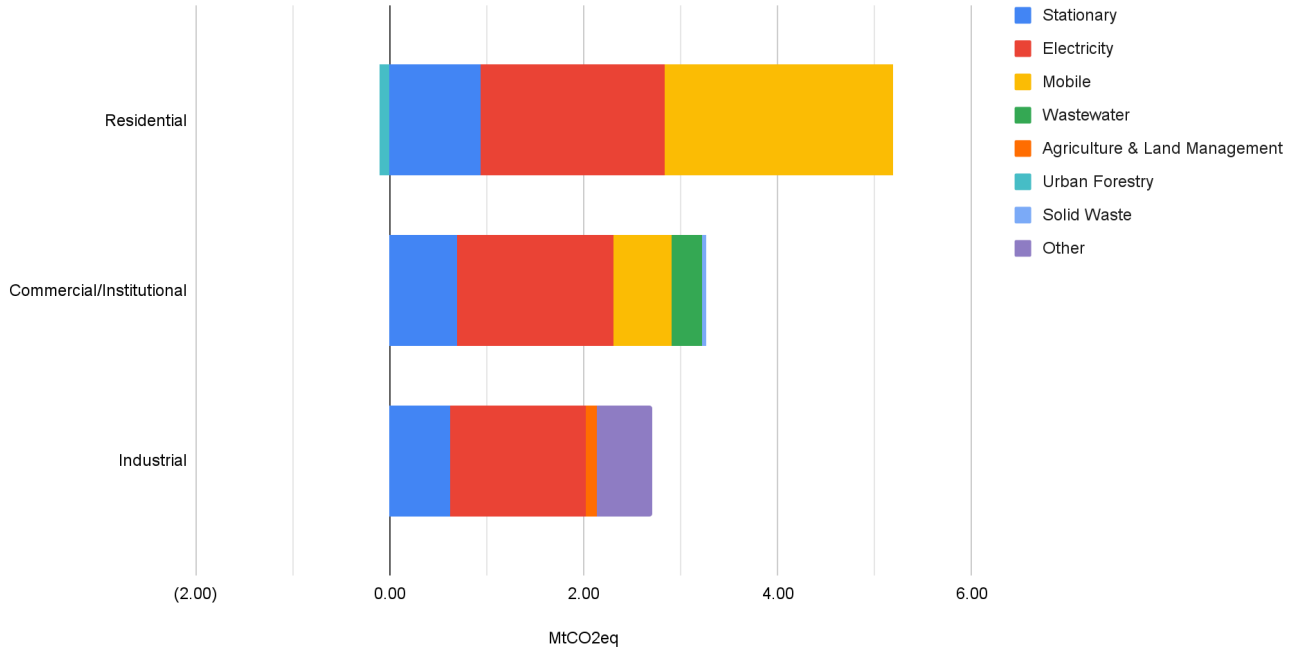

Figure 1. GHG Emissions by Sector, 2021

2 Scope

2.1 Accounting Protocol

The accounting protocol for this GHG inventory is the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC).[1]

2.2 Background Information

Table 1. Background information

Name of jurisdiction	Dayton Kettering MSA
State	Ohio
Inventory year	2021
Geographic boundary	Greene, Miami and Montgomery Counties

[1] World Resources Institute et al. (2021). Global Protocol for Community-Scale Greenhouse Gas Inventories. Retrieved from: https://ghgprotocol.org/ghg-protocol-cities

Land area (km2)	4,440
Resident population	811, 078
GDP	$49.5 billion (2021)[2]
Composition of economy	483,000 jobs: Health care- 16%; Government- 16%; Retail- 11%; Manufacturing- 10%; Professional, scientific and technical services- 9%; Accommodation and food services- 8%; Other- 30%.[3]
Climate	Dayton's climate features hot, humid summers and cold, dry winters.[4]

2.3 Reporting Sectors

Table 2 describes the sectors included and the rationale for exclusions according to the requirements of GPC.

Table 2. Reporting Sectors

Sector	**Inclusion**	**Rationale**
Stationary Energy		
Residential buildings	Yes	
Commercial and institutional buildings and facilities	Yes	
Manufacturing industries and construction	Yes	
Energy industries	Yes	
Agriculture, forestry, and fishing activities	No	IE
Non-specified sources	No	NO
Fugitive emissions from mining, processing, storage, and transportation of coal	No	NO
Fugitive emissions from oil and natural gas systems	No	NE
Transportation		

[2] U.S. Bureau of Economic Analysis (2023). CAGDP1 County and MSA gross domestic product (GDP) summary. Retrieved from: https://apps.bea.gov/iTable/?reqid=70&step=1&isuri=1&acrdn=5#eyJhcHBpZCI6NzAsInN0ZXBzIjpbMSwyOSwyNSwzMSwyNiwyNywzMF0sImRhdGEiOltbIlRhYmxlSWQiLCI1MzMiXSxbIk1ham9yX0FyZWEiLCI1Il0sWyJTdGF0ZSIsWyI1Il1dLFsiQXJlYSIsWyIxOTQzMCJdXSxbIlN0YXRpc3RpYyIsWyIzIl1dLFsiVW5pdF9vZl9tZWFzdXJlIiwiTGV2ZWxzIl0sWyJZZWFyIixbIjIwMjEiXV0sWyJZZWFyQmVnaW4iLCItMSJdLFsiWWVhcl9FbmQiLCItMSJdXX0=

[3] U.S. Bureau of Economic Analysis (2023). CAEMP25N Total full-time and part-time employment by NAICS industry 1. Retrieved from: https://apps.bea.gov/iTable/?reqid=70&step=1&isuri=1&acrdn=5#eyJhcHBpZCI6NzAsInN0ZXBzIjpbMSwyOSwyNSwzMSwyNiwyNywzMF0sImRhdGEiOltbIlRhYmxlSWQiLCIzMyJdLFsiTWFqb3JfQXJlYSIsIjUiXSxbIlN0YXRlIixbIjUiXV0sWyJBcmVhIixbIjE5NDMwIl1dLFsiU3RhdGlzdGljIixbIi0xIl1dLFsiVW5pdF9vZl9tZWFzdXJlIiwiTGV2ZWxzIl0sWyJZZWFyIixbIjIwMjEiXV0sWyJZZWFyQmVnaW4iLCItMSJdLFsiWWVhcl9FbmQiLCItMSJdXX0=

[4] Great Lakes Integrated Sciences + Assessments (2013). Historical Climatology: Dayton, Ohio. Retrieved from: /https://graham.umich.edu/media/files/GLAA-C/Dayton/DaytonOH_Climatology.pdf

On-road	Yes	
Railways	No	NO
Waterborne navigation	No	NO
Aviation	No	NE
Off-road	No	NE
Waste		
Solid waste disposal	Yes	
Biological treatment of waste	No	NO
Incineration and open burning	No	NO
Wastewater treatment and discharge	Yes	
Industrial Processes and Product Use		
Industrial processes	Yes	
Product use	No	NO
Agriculture, Forestry and Other Land-Use (AFOLU)		
Livestock	No	NE
Land	No	NE
Aggregate sources and non-CO2 emission sources on land	Yes	

Table 3. Exclusion Rationale Notations

Notation	Definition	Description
IE	Included Elsewhere	GHG emissions for this activity are estimated and presented in another category of the inventory.
NE	Not Estimated	Emissions occur but have not been estimated or reported; justification for exclusion shall be noted in the explanation.
NO	Not Occurring	An activity or process does not occur or exist within the city.
C	Confidential	GHG emissions which could lead to the disclosure of confidential information and can therefore not be reported.

3 Method

3.1 Inventory Tool

EPA's Local Greenhouse Gas Inventory Tool ("Inventory Tool") was used to develop the GHG Inventory. The Inventory Tool is attached as Appendix 2.

3.2 Data Sources

Table 4. GHG Inventory Data Sources

Inventory Tool Sector	Data Source
Stationary	U.S. Energy Information Administration Natural Gas Consumption by End Use Form EIA-176: Annual Report of Natural and Supplemental Gas Supply and Disposition, 2021
Electricity	U.S. Energy Information Administration Electricity Sales to Ultimate Customers Form EIA-861: Annual Electric Power Industry Report, 2021
Mobile	U.S. Federal Highway Administration Highway Statistics, 2021 Table VM-2 Vehicle-miles of travel, by functional system
Mobile	U.S. Federal Highway Administration Highway Statistics, 2021 Table VM-4 Distribution of Annual Vehicle Distance Traveled
Stationary, Electricity, Mobile	National Renewable Energy Laboratory Net Electricity and Natural Gas Consumption, Reference Case[5] State and Local Planning for Energy
Additional Emissions Sources	U.S. Environmental Protection Agency, Office of Atmospheric Protection Greenhouse Gas Reporting Program, 2021 Emissions by Unit and Fuel Type
Additional Emissions Sources	U.S. Environmental Protection Agency, Office of Atmospheric Protection Greenhouse Gas Reporting Program, 2021 Facility Level Information on GHGs Tool
Additional Emissions Sources	U.S. Environmental Protection Agency, Office of Atmospheric Protection Greenhouse Gas Reporting Program, 2021 Facility Report: Fairborn Cement Company LLC
Additional Emissions Sources	U.S. Environmental Protection Agency, Office of Atmospheric Protection Greenhouse Gas Reporting Program, 2021 Facility Report: Cargill Incorporated
Agriculture	U.S. Department of Agriculture National Agricultural Statistics Service, Quick Stats, 2020-2021 Commodity: Corn, Soybeans Data Item: Acres Planted, Fertilizer (Nitrogen) Applications
Urban Forestry	U.S. Forestry Service National Land Cover Database Tree Cover Canopy maps, 2021
Urban Forestry	Miami Valley Regional Planning Commission Miami Valley Geo-Spark 2020 Urban Area for the Miami Valley, Ohio
Solid Waste	U.S. Environmental Protection Agency, Office of Atmospheric Protection

[5] Data used to allocate Ohio energy consumption to the Dayton Kettering MSA counties.

	Greenhouse Gas Reporting Program, 2021 Facility Report: Stony Hollow Landfill, Inc.
Wastewater	Miami Valley Regional Planning Commission Miami Valley Geo-Spark Areawide 208/201 Facilities Planning Area (FPA) information
Wastewater	Miami Valley Regional Planning Commission Miami Valley Geo-Spark Population - Block Group

3.3 Global warming potential

Table 5. Global Warming Potentials (100-yr)[6]

CO2 to CO2e	1
CH4 to CO2e	30
N2O to CO2e	273

3.4 Emissions Factors

Table 6. Fuel Emissions Factors[7]

Fuel	kg CO2	kg CH4	kg N2O	Heat Content (MMBtu/unit)	Unit
Natural Gas	54.863	0.0049	0.0001	1.0370	mcf
Digester Gas	34.106	0.0021	0.0004	0.6550	mcf
Diesel	10.21	0.0004	0.00008	0.1381	gal
LPG	6.02	0.0003	0.00006	0.0920	gal
Gasoline	8.50	0.0004	0.00007	0.1202	gal
Residual Fuel Oil No. 5	10.21	0.0004	0.00008	0.1400	gal
Residual Fuel Oil No. 6	11.27	0.0005	0.00009	0.1500	gal
Propane	5.72	0.0003	0.00005	0.0910	gal
Butane	6.67	0.0003	0.00006	0.1030	gal
Jet Fuel	9.75	0.0004	0.00008	0.1350	gal

[6] Arias, P.A., N. Bellouin, E. Coppola, R.G. Jones, G. Krinner, J. Marotzke, V. Naik, M.D. Palmer, G.-K. Plattner, J. Rogelj, M. Rojas, J. Sillmann, T. Storelvmo, P.W. Thorne, B. Trewin, K. Achuta Rao, B. Adhikary, R.P. Allan, K. Armour, G. Bala, R. Barimalala, S. Berger, J.G. Canadell, C. Cassou, A. Cherchi, W. Collins, W.D. Collins, S.L. Connors, S. Corti, F. Cruz, F.J. Dentener, C. Dereczynski, A. Di Luca, A. Diongue Niang, F.J. Doblas-Reyes, A. Dosio, H. Douville, F. Engelbrecht, V. Eyring, E. Fischer, P. Forster, B. Fox-Kemper, J.S. Fuglestvedt, J.C. Fyfe, N.P. Gillett, L. Goldfarb, I. Gorodetskaya, J.M. Gutierrez, R. Hamdi, E. Hawkins, H.T. Hewitt, P. Hope, A.S. Islam, C. Jones, D.S. Kaufman, R.E. Kopp, Y. Kosaka, J. Kossin, S. Krakovska, J.-Y. Lee, J. Li, T. Mauritsen, T.K. Maycock, M. Meinshausen, S.-K. Min, P.M.S. Monteiro, T. Ngo-Duc, F. Otto, I. Pinto, A. Pirani, K. Raghavan, R. Ranasinghe, A.C. Ruane, L. Ruiz, J.-B. Sallée, B.H. Samset, S. Sathyendranath, S.I. Seneviratne, A.A. Sörensson, S. Szopa, I. Takayabu, A.-M. Tréguier, B. van den Hurk, R. Vautard, K. von Schuckmann, S. Zaehle, X. Zhang, and K. Zickfeld, 2021: Technical Summary. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 33–144. doi: 10.1017/9781009157896.002.

[7] The Climate Registry 2021 Default Emission Factors and Emissions Factors for Greenhouse Gas Inventories, U.S EPA April 2022

Residential Coal	2390.90	0.2742	0.03989	24.9300	short tons
Commercial Coal	2051.40	0.2353	0.03422	21.3900	short tons
Industrial Coal	2138.58	0.2459	0.03576	22.3500	short tons
Electric Power Coal	1890.52	0.2170	0.03157	19.7300	short tons
Distillate Fuel Oil	10.281	0.0004	0.00008	0.1387	gal
Kerosene	10.150	0.0004	0.00008	0.1350	gal

Table 7. Emission Factors Per MMBtu[8]

Fuel	kg CO2	kg CH4	kg N2O	MMBtu/Unit	
Natural Gas	52.91	0.0047	0.0001	0.001037	MMBtu/scf
Digester Gas	52.07	0.0032	0.00063	0.000655	MMBtu/scf
Jet Fuel	72.22	0.003	0.0006	0.135	MMBtu/gal
Residential Coal	95.90	0.011	0.0016	24.93	MMBtu/short ton
Commercial Coal	95.90	0.011	0.0016	21.39	MMBtu/short ton
Industrial Coal	95.69	0.011	0.0016	22.35	MMBtu/short ton
Electric Power Coal	95.82	0.011	0.0016	19.73	MMBtu/short ton

Table 8. eGRID Electricity Emission Factors for RFC West Subregion[9]

Fuel	lbs CO2/MWh	lbs CH4/MWh	lbs N2O/MWh
Electricity	1,046.13	0.095	0.014

3.5 Business as Usual (BAU) projection

The BAU projection is an extrapolation of GHG emissions from 2022 to 2050 using EPA's State Inventory and Projection Tool.[10] The primary input into this tool is a population projection, which is derived from state projections from the U.S. Census Bureau[11] through 2030 and national projections[12] through 2050 apportioned to states based on the 2030 population. Outputs from the tool include fuel consumption by sector. The projected fuel consumption is divided by the state population to derive a per capita fuel consumption rate by sector and fuel type through 2050. This per capita consumption is multiplied by county population projections to estimate future fuel use by sector, fuel type, and county.

County population projections come from the Miami Valley Regional Planning Commission's 2050 Long Range Transportation Plan (LRTP).[13] Each county's 2050 population in the LRTP is used as the target with linear interpolation applied for the intervening years.

Table 8. Population projection by County

[8] Ibid.

[9] Emissions & Generation Resource Integrated Database (eGRID). https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

[10] EPA (2023). State Inventory and Projection Tool. Retrieved from: https://www.epa.gov/statelocalenergy/state-inventory-and-projection-tool

[11] U.S. Census Bureau. "Current Population Reports, 1995-2030"

[12] U.S. Census Bureau. "The Baby Boom Cohort in the United States: 2012 to 2060"

[13] Miami Valley Regional Planning Commission. (2021, May). 2050 Long Range Transportation Plan. https://www.mvrpc.org/sites/default/files/lrtp21-Chapter3.pdf

County	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Greene	167,043	167,830	168,618	169,405	170,192	170,980	171,767	172,554	173,341	174,129
Miami	107,899	108,223	108,547	108,871	109,195	109,519	109,843	110,167	110,491	110,815
Montgomery	536,136	534,573	533,011	531,448	529,885	528,323	526,760	525,197	523,635	522,072
Total	811,078	810,627	810,175	809,724	809,273	808,821	808,370	807,919	807,467	807,016

County	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Greene	174,916	175,703	176,491	177,278	178,065	178,853	179,640	180,427	181,215	182,002
Miami	111,139	111,463	111,787	112,111	112,435	112,759	113,083	113,407	113,731	114,055
Montgomery	520,509	518,947	517,384	515,821	514,259	512,696	511,134	509,571	508,008	506,446
Total	806,565	806,113	805,662	805,211	804,759	804,308	803,856	803,405	802,954	802,502

County	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Greene	182,789	183,577	184,364	185,151	185,938	186,726	187,513	188,300	189,088	189,875
Miami	114,379	114,703	115,027	115,351	115,675	115,999	116,323	116,647	116,971	117,295
Montgomery	504,883	503,320	501,758	500,195	498,632	497,070	495,507	493,944	492,382	490,819
Total	802,051	801,600	801,148	800,697	800,246	799,794	799,343	798,892	798,440	797,989

Emissions factors are applied to the fuel consumption to determine emissions. The emissions factors for non-electricity fuels are shown in Table 7. The projected emissions factor for grid electricity is based on the trend in Ohio electricity sector emissions and demand from the Energy Policy Simulator (EPS) by the Rocky Mountain Institute (RMI).[14] In the EPS model, fuel use for electricity generation is forecasted based on existing capacity, estimated demand, electricity generation costs, and policy assumptions such as state renewable portfolio standards.

Solid waste and wastewater emissions are scaled based on projected population. Agriculture and urban forestry emissions are held constraint from 2021 through 2050.

4 Results

4.1 Emissions by sector

Total GHG emissions for Dayton Kettering MSA in 2021 totaled 11 MMtCO2e, with the majority of emissions coming from the residential sector (47%), followed by commercial/institutional (29%) and industrial (24%).

[14] https://rmi.org/energy-policy-simulator/

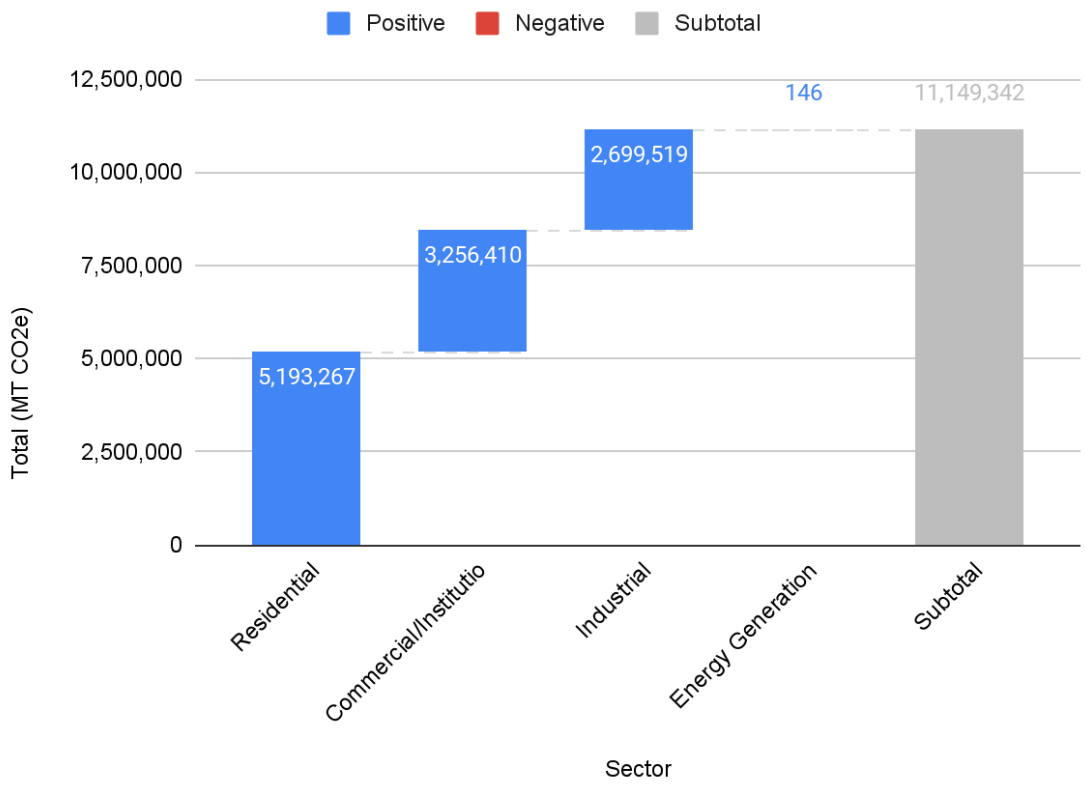

Figure 2. GHG Emissions by Sector, 2021, excluding agriculture and forestry

GHG emissions in the residential sector are dominated by transportation emissions (47%). The commercial/institutional and industrial sectors are dominated by emissions from electricity (50% and 52% respectively).

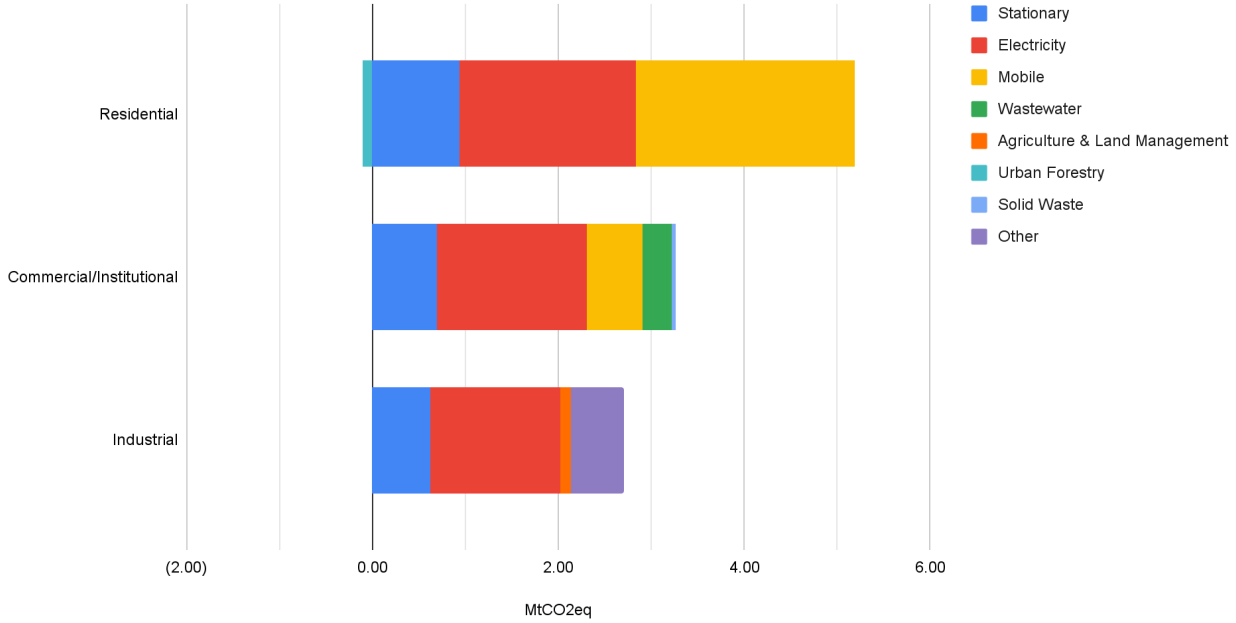

Figure 3. GHG emissions with sectoral components, 2021

4.2 Emissions by sub-sector

Electricity is the major source of GHG emissions overall (43% of the total), followed by transportation emissions (28%) and stationary emissions (natural gas) (20%). Decarbonising electricity would cut the region's GHG emissions by nearly 5 MMtCO2e.

Wastewater treatment, agriculture and land management and waste management represent less than 4% of the total emissions (<0.5 MMtCO2e). Urban forests reduce emissions by 0.1 MMtCO2e.

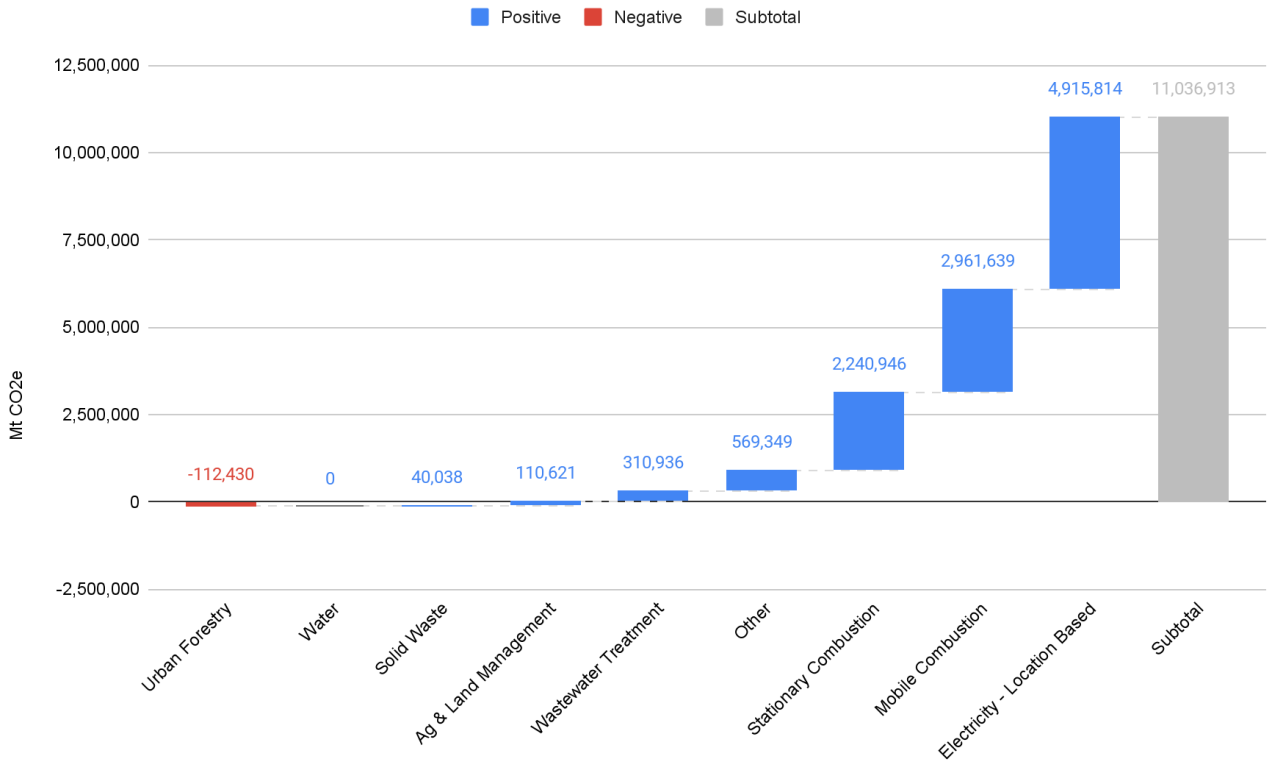

Figure 4. GHG Emissions by Sub-Sector, 2021

4.3 Emissions by scope

Scope 1 GHG emissions total 6.3 MMtCO2e while scope 2 GHG emissions were 4.9 MMtCO2e, which are primarily emissions resulting from electricity generation outside of the MSAs boundaries. No GHG emissions from scope 3 were tracked.

Table 9. Reporting Sectors

Scope	Definition
Scope 1	GHG emissions from sources located within the boundary of the MSA.
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the boundary of the MSA.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities

	taking place within the boundary of the MSA.

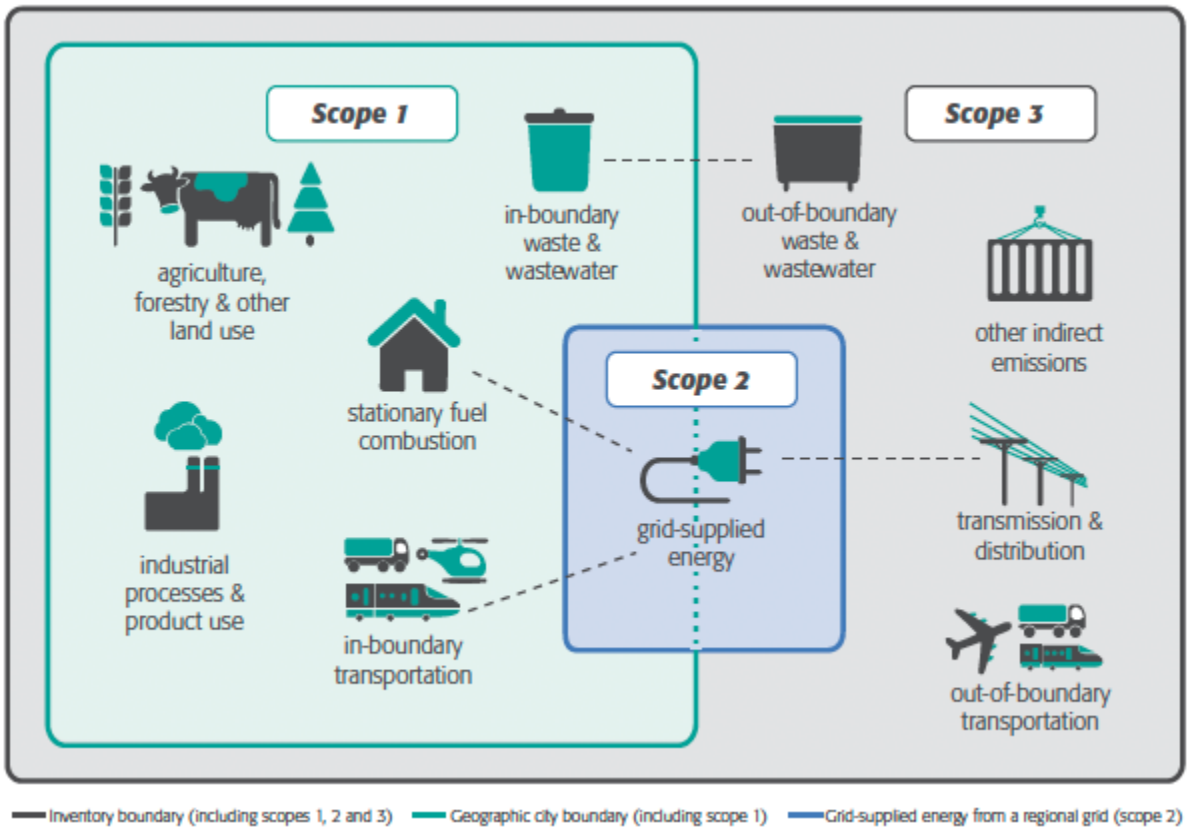

Figure 5. Illustration of Scopes

Scope 1 GHG emissions dominate the inventory, while scope 2 emissions are from electricity. This inventory does not report on any scope 3 GHG emissions.

Figure 6. GHG Emissions by Scope, 2021

4.4 Emissions by gas

When all the GHG emissions have been normalised to carbon dioxide equivalents (see section 3.3 on Global Warming Potential), CO2 is the dominant source of emissions.

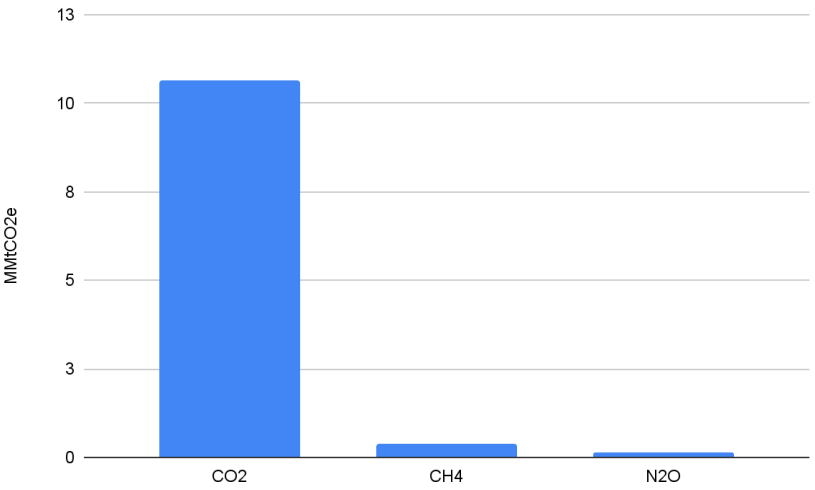

Figure 7. GHG Emissions by Scope, 2021

CO2 emissions are directly correlated to combustion with fossil fuels, as illustrated in Figure 8.

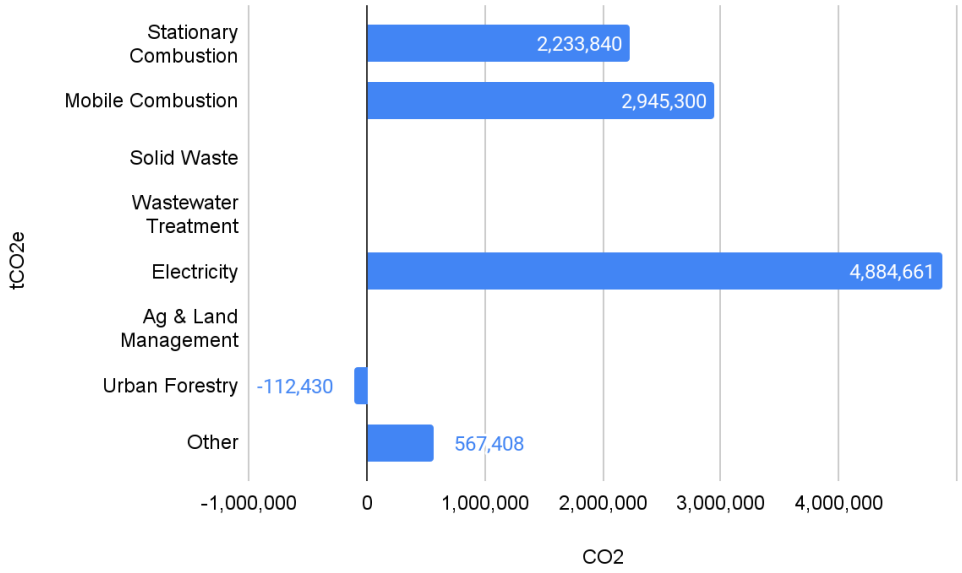

Figure 8. GHG Emissions, CO2, 2021

The largest source of methane emissions is wastewater treatment, followed by solid waste. Note that if a twenty year GWP is used for methane (85 instead of 30), methane emissions would nearly triple.[15] A twenty year GWP reflects the importance of reducing GHG emissions in the near future, but it is not standard in GHG emissions reporting protocols.[16]

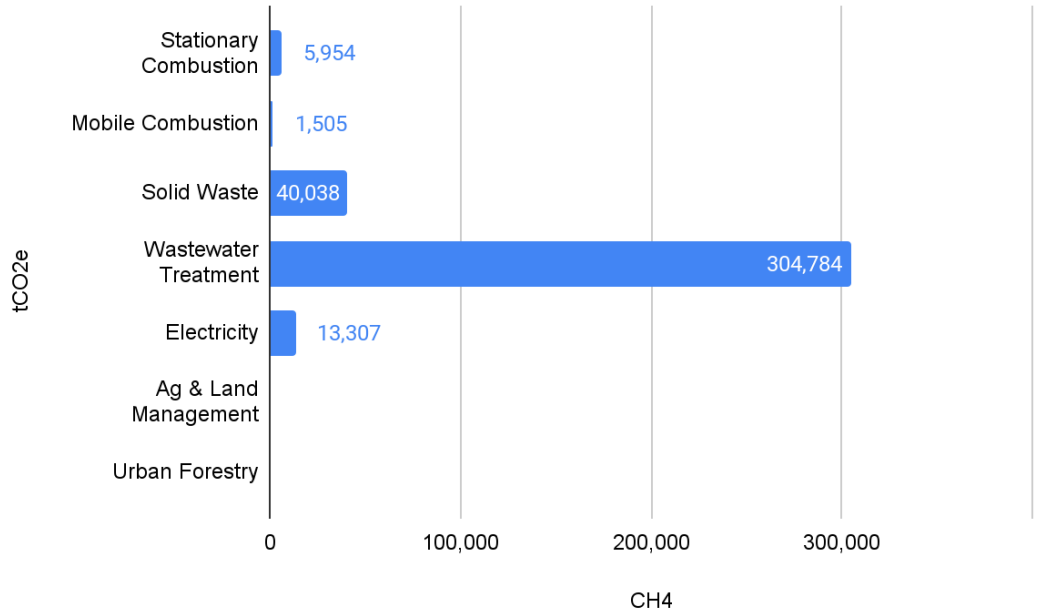

Figure 9. GHG Emissions, CH4, 2021

[15] IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.pp. 1017

[16] EPA (2023). Understanding Global Warming Potentials. Retrieved from: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

Nitrous oxides are primarily from agricultural and land management.

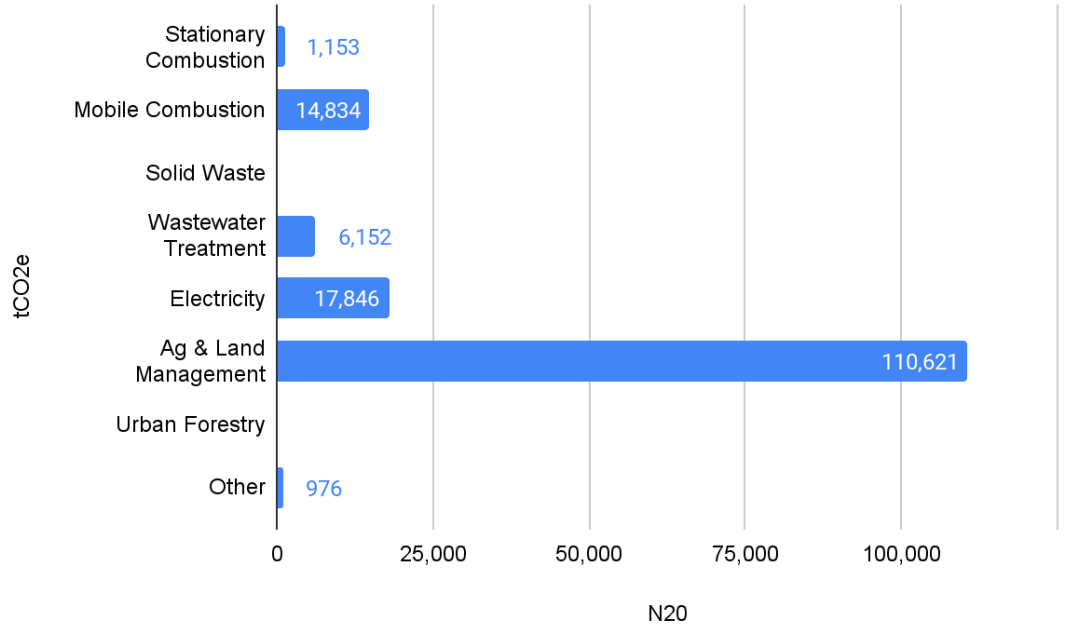

Figure 10. GHG Emissions, N2O, 2021

4.5 Energy and emissions shares

Electricity accounts for 45% of the total energy but 69% of the total emissions, illustrating the potential for GHG emissions emissions reductions from this sector, particularly given the low cost of renewable electricity generation.[17]

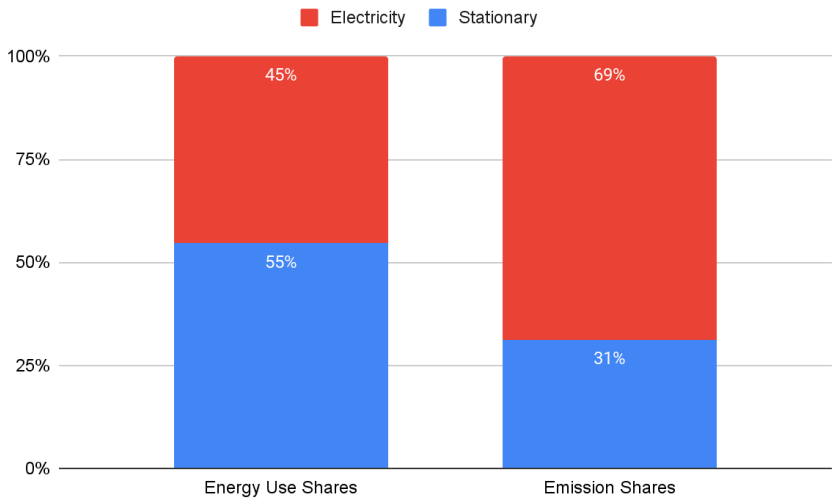

Figure 11. GHG Emissions by Scope, 2021

[17] IEA (2022). Renewable power's growth is being turbocharged as countries seek to strengthen energy security. Retrieved from: https://www.iea.org/news/renewable-power-s-growth-is-being-turbocharged-as-countries-seek-to-strengthen-energy-security

An additional challenge for the electricity system is that the pathway to decarbonise the energy system requires electrifying most of the 55% of the energy demand that is currently powered by natural gas, gasoline and diesel.

4.6 Total energy use

The residential sector uses the most energy, as would be expected. Total energy consumption across all sectors is 42 million MMBTU.

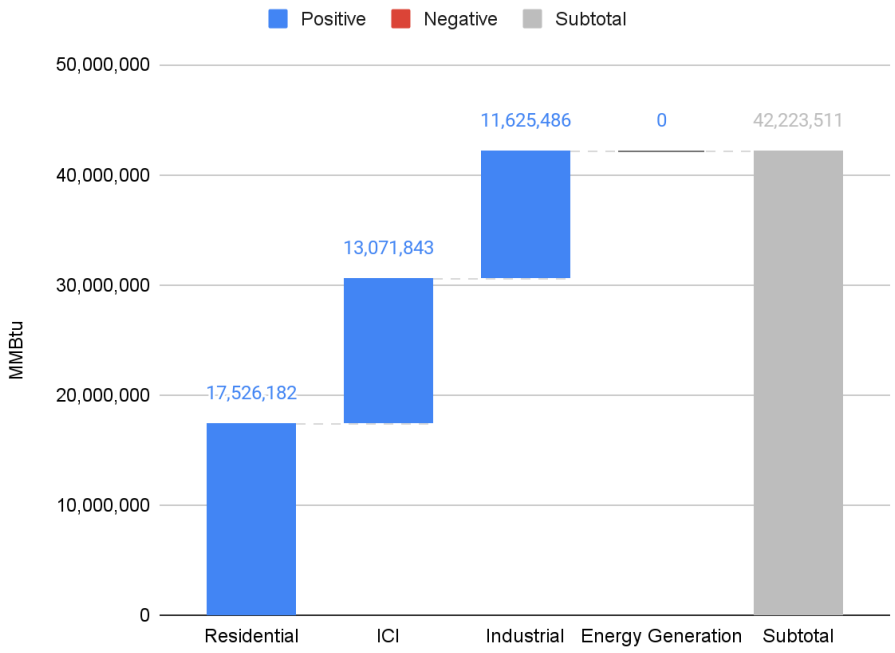

Figure 12. Energy Consumption by Sector, 2021

4.7 Electricity consumption

Electricity's share of stationary energy for the residential, commercial/institutional and industrial sectors is 77%, 47% and 46% respectively.

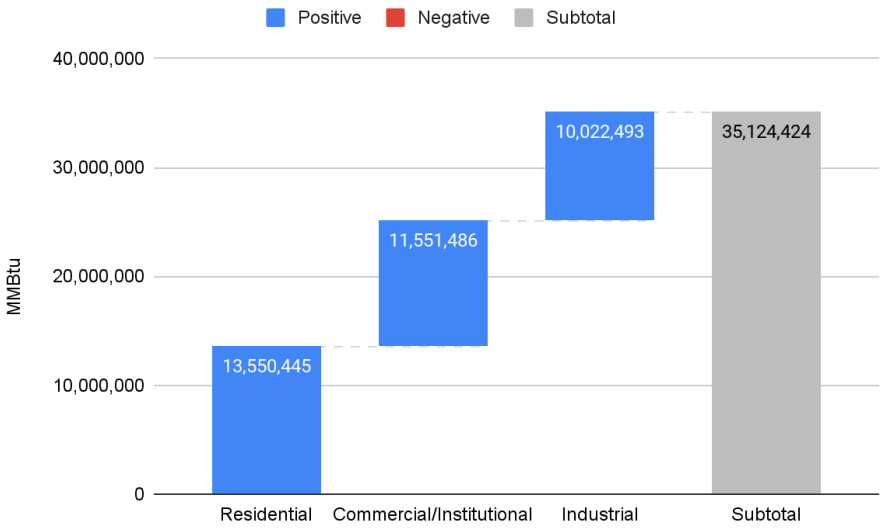

Figure 13. Electricity Consumption by Sector, 2021

4.8 Comparison with Dayton's GHG inventory

The City of Dayton completed a GHG inventory in 2019, which is a narrower geographic scope than Dayton Kettering MSA. Figure 14 illustrates a share-based comparison of the two inventories. The two inventories with small variation by sector. In both cases, the largest share of emissions is from electricity, with a slightly higher share in Dayton. Dayton Kettering MSA has a slightly higher share of emissions from transportation (mobile combustion) and natural gas (stationary combustion).

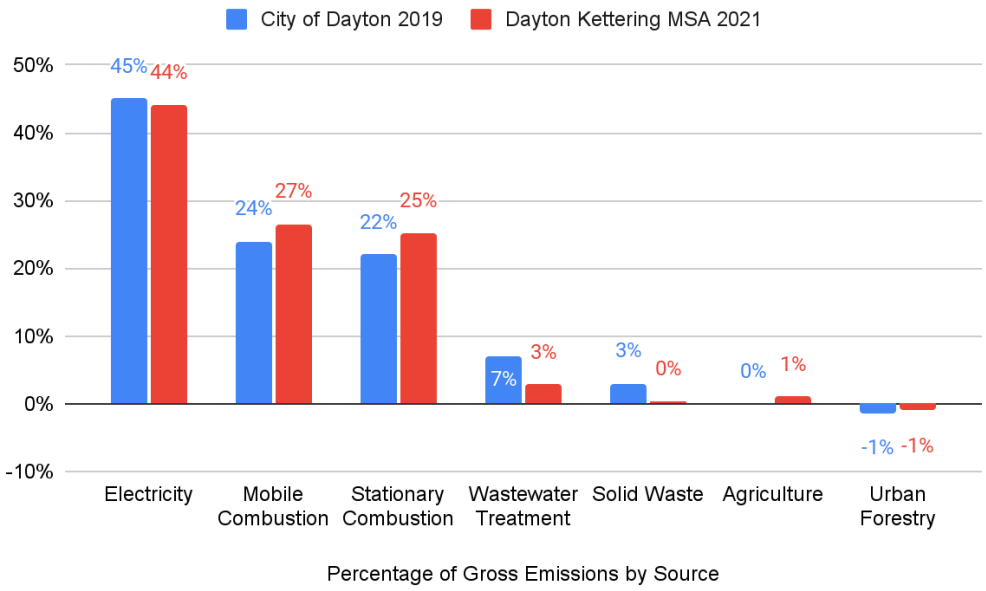

Figure 14. Comparison of inventories by sector by share for Dayton (2019) and Dayton Kettering MSA (2021)

4.9 Business as Usual Projection

GHG emissions are projected to decrease even though total energy consumption is projected to increase.

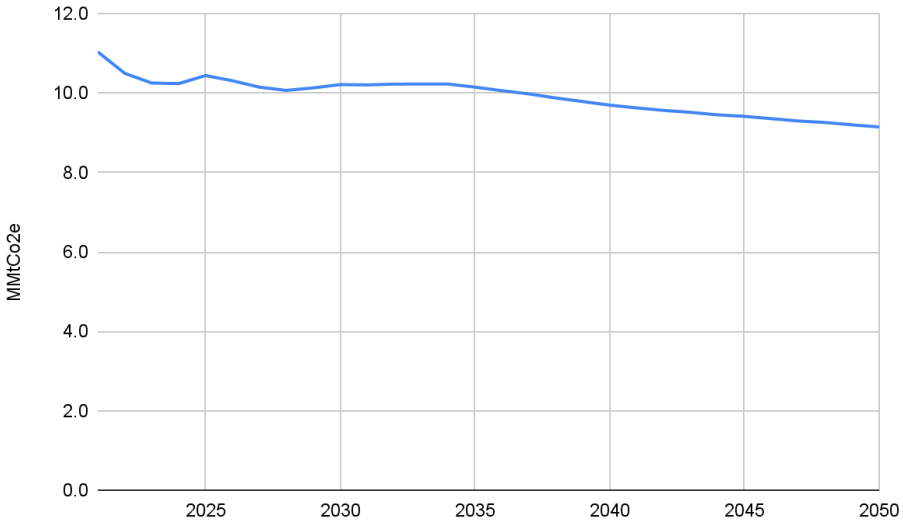

Figure 15. Total GHG emissions, 2019-2050

The decrease in emissions is the result of increasingly cleaner electricity driven by decreasing costs for wind and solar.

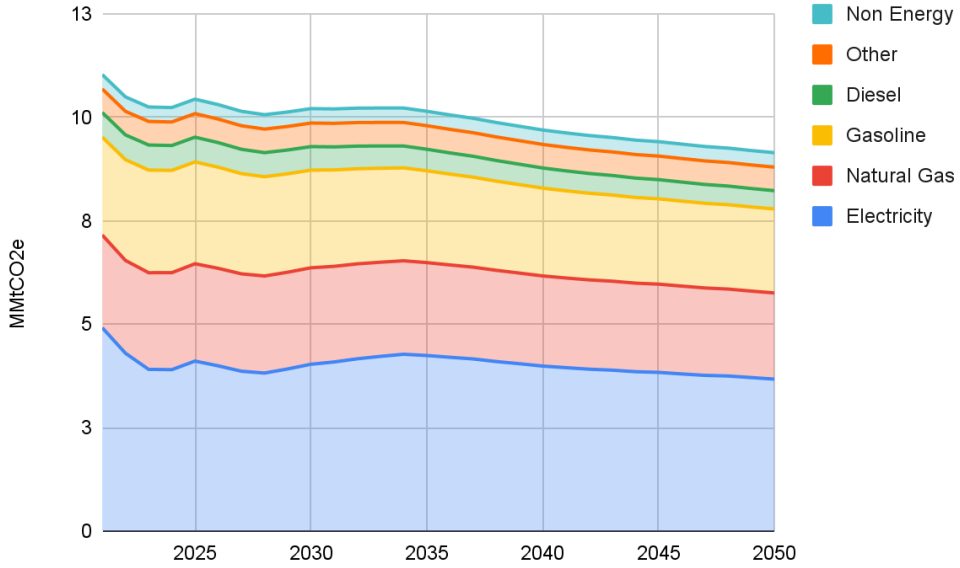

Figure 16. GHG emissions by fuel and non-fuel sources, 2019-2050

There is a slight decrease in energy use in the transportation sector, based on a projection of increased vehicle efficiency from the EPA's state projection tool.

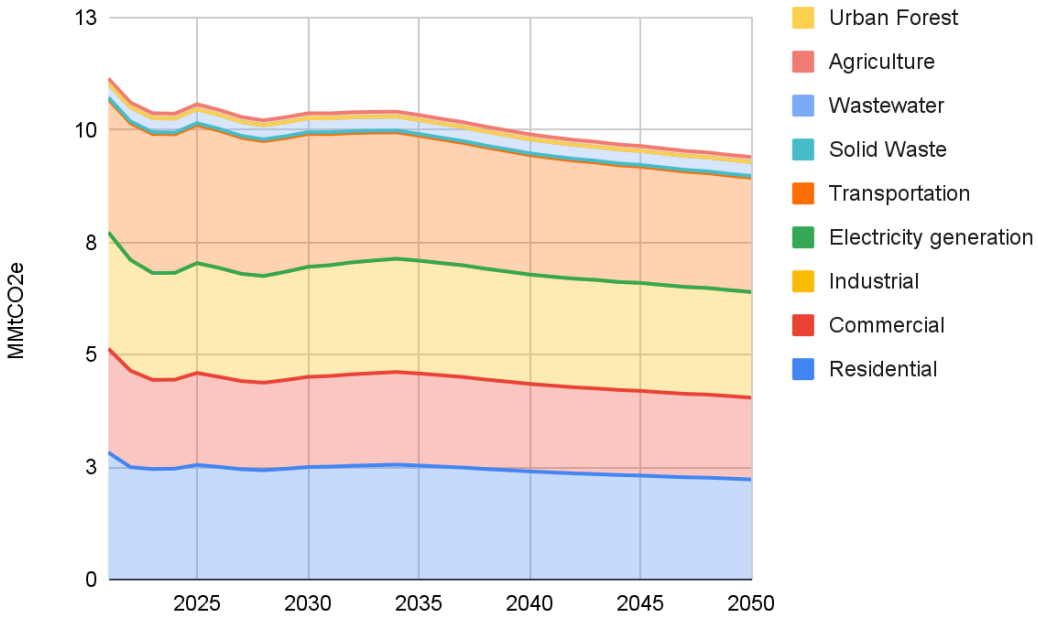

Figure 17. GHG emissions by sector, 2019-2050

5 Conclusion

Dayton Kettering MSA's GHG emissions are dominated by electricity, which is a clear opportunity for rapid and deep emissions reductions, given that relevant technologies are proven and cost-effective.

Notably, residential GHG emissions are the largest sector, followed by commercial/institutional and lastly industrial. This order of emissions is also an opportunity as the benefits of residential GHG emissions will directly benefit households and can be targeted to low income and disadvantaged communities.

In parallel to reducing the GHG intensity of electricity, Dayton Kettering also needs to fuel switch equipment in buildings (heating and cooling) and vehicles.

6 Glossary

Term	Definition
Base Year	A measurement, calculation, or time used as a basis for comparison. According to LGOP, it is good practice to aim for a base year that is likely to be representative of the general level of emissions over the surrounding period.
BAU	Business As Usual. Used to refer to a future scenario in which there are no changes to the status quo.
Biogenic	Biogenic emissions or fuels are produced by the biological processes of living organisms. Note that this term refers only to recently produced (i.e., non-fossil) material of biological origin
BOD_5	Biological Oxygen Demand. The amount of oxygen consumed in five days by decomposing waste, used to measure the amount of waste input or output into a system.
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent emissions. This is determined by multiplying the emissions of methane and nitrous oxide by their Global Warming Potential.
CH_4	Methane. Methane is a greenhouse gas with a GWP that is 25 times that of CO_2. It is produced through anaerobic decomposition of waste, enteric fermentation, production of natural gas and petroleum products, and other industrial processes.
Direct Emissions	The emissions generated on-site (as opposed to electricity delivered through a grid system), such as from the combustion of fossil fuels
EF	Emission Factor. The value for scaling emissions to activity data in terms of a standard rate of emissions per unit of activity (e.g., grams of carbon dioxide emitted per barrel of fossil fuel consumed).
Effluent	The treated or untreated wastewater that flows out of a source
EPA	United States Environmental Protection Agency
EPS	Energy Policy Simulator
Fossil Fuel	Any fuel derived from the pre-historic burial of organic matter. Examples include natural gas (methane or CH_4) and petroleum products (gasoline, diesel, kerosene, propane, and others). Combustion of petroleum products releases greenhouse gases into the atmosphere.
Fugitive Emissions	Emissions of gases that escape from pressurized equipment, such as fuel transportation pipelines or wastewater treatment plants.
GHG	greenhouse gas
GPC	Global Protocol for Community-Scale GHG Emissions
GWP	Global Warming Potential. Conversion factor used to compare all greenhouse gas emissions to carbon dioxide equivalent units. The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing thermal infrared radiation.

Indirect Emissions	Refers to indirect emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling. These emissions can be allocated in an inventory to an entity, but are generated offsite. An example is electricity that is not generated directly at a facility. A facility uses electricity on-site, but the fuels used to generate the electricity are combusted off-site, perhaps at a regional power plant. If the generation source is at a different site that is also operated by the community, it is not an indirect emission source.
kg	kilograms
kWh	kilowatt-hour
LFG	landfill gas
mcf	thousand cubic feet of natural gas
MMBtu	million British Thermal Units, a measure of energy
Mobile Combustion	The combustion of fuels to power a moving vehicle, such as gasoline or diesel fuel in a car or truck
MT CO_2e	Metric tons of carbon dioxide equivalent. This is the standard unit for measuring greenhouse gas emissions.
N_2O	nitrous oxide
Nitrification	Biological process in which ammonia is converted to nitrate (NO_3).
Scope 1 Emissions	All direct GHG emissions
Scope 2 Emissions	Indirect GHG emissions from the consumption of purchased electricity, heat, or steam.
Scope 3 Emissions	Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, outsourced activities, etc. The Scope 3 emissions included in this inventory are imported water consumption, waste generation, urban forestry, and agriculture & land management.
Stationary Combustion	The on-site combustion of fuels to produce electricity, heat, or motive power using equipment in a fixed location

7 Appendix 1. Tables of Results

Total Dayton Kettering MSA Emissions (MT CO2e)								
	CO2	**CH4**	**N2O**	**HFCs**	**PFCs**	**SF6**	**Total MT CO2e**	**Percent of Total**
Scope 1	5,746,548	353,245	23,115	-	-	-	6,122,908	55%
Scope 2 - Location Based	4,884,661	13,307	17,846	-	-	-	4,915,814	45%
Scope 2 - Market Based (for informational purposes only)	4,884,661	13,307	17,846				4,915,814	
Scope 3	-	-	-	-	-	-	0	0%
Total Gross Emissions	**10,631,209**	**366,552**	**151,582**	**-**	**-**	**-**	**11,149,343**	**99%**
Total Net Emissions	**10,518,779**	**366,552**	**151,582**	**-**	**-**	**-**	**11,036,913**	**99%**

Emissions by Source (MT CO2e)								
Source	**CO2**	**CH4**	**N2O**	**HFCs**	**PFCs**	**SF6**	**Total**	**Percent of Total**
Stationary Combustion	2,233,840	5,954	1,153	-	-	-	2,240,946	20%
Mobile Combustion	2,945,300	1,505	14,834	-	-	-	2,961,639	27%
Solid Waste	-	40,038	-	-	-	-	40,038	0.4%
Wastewater Treatment	-	304,784	6,152	-	-	-	310,936	3%
Electricity - Location Based	4,884,661	13,307	17,846	-	-	-	4,915,814	44%
Electricity - Market Based (for informational purposes only)	4,884,661	13,307	17,846				4,915,814	44%
Water	-	-	-	-	-	-	0	0%
Ag & Land Management	-	-	110,621				110,621	1%
Urban Forestry	-112,430	-	-				-112,430	-1%
Waste Generation	-	-	-				0	0%
Other	567,408	965	976	-	-	-	569,349	5%
Total (Gross Emissions)	**10,631,209**	**366,552**	**151,582**	**-**	**-**	**-**	**11,149,343**	**100%**
Total (Net Emissions)	**10,518,779**	**366,552**	**151,582**	**-**	**-**	**-**	**11,036,913**	**99%**

Gross Emissions by Sector		
Sector	**Total (MT CO2e)**	**Percent of Total**
Residential	5,193,267	47%
Commercial/Institutional	3,256,410	29%
Industrial	2,699,519	24%
Energy Generation	146	0%
Total	**11,149,342**	**100%**

Total Emissions by Sector and Source (MT CO2e)											
Sector	**Stationary**	**Electricity**	**Mobile**	**Solid Waste**	**Wastewater**	**Water**	**Agriculture & Land Management**	**Urban Forestry**	**Other**	**TOTAL GROSS**	**TOTAL NET**
Residential	930,175	1,896,443	2,366,649					-112,430	0	5,193,267	5,080,837
Commercial/Institutional	693,767	1,616,680	594,989	40,038	310,936				0	3,256,410	3,256,410
Industrial	617,004	1,402,691					110,621		569,203	2,699,519	2,699,519
Energy Generation									146	146	146

Total	2,240,946	4,915,814	2,961,638	40,038	310,936	0	110,621	-112,430	569,349	**11,149,342**	**11,036,913**

Fuel and Energy (MMBtu) Use by Sector				
Sector	**mcf**	**gal**	**tons**	**Energy Use**
Residential	16,900,851	-	-	17,526,182
Commercial/Institutional	12,605,442	-	-	13,071,843
Industrial	11,210,690	-	-	11,625,486
Energy Generation	-	-	-	-
Total Stationary Combustion Energy Use	40,716,983	-	-	**42,223,511**

Electricity Use by Sector (in kWh)	
Sector	**kWh**
Residential	3,971,243,504
ICI	3,385,406,513
Industrial	2,937,303,019
Energy Generation	
Total Electricity Use	**10,293,953,036**

Table: Business as Usual Projection, Dayton Kettering MSA

Sector	Emissions - MT CO2e	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Residential	Electricity	1,896,434	1,601,772	1,478,101	1,482,114	1,562,491	1,519,785	1,471,569	1,456,412	1,494,989	1,539,626
	Natural Gas	930,260	896,893	978,421	983,651	986,599	984,509	980,217	974,558	967,742	961,833
Commercial	Electricity	1,616,673	1,430,592	1,276,982	1,271,022	1,332,769	1,288,085	1,244,405	1,228,183	1,257,155	1,289,780
	Natural Gas	693,831	717,009	707,075	709,626	713,778	715,037	718,812	719,559	717,806	716,544
Industrial	Electricity	1,402,685	1,266,541	1,155,089	1,151,468	1,217,975	1,191,657	1,154,413	1,142,421	1,176,262	1,213,585
	Natural Gas	617,061	630,860	653,923	654,947	658,127	664,880	663,441	662,420	663,947	665,867
	Other	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203
Electricity Generation	Other	146	146	146	146	146	146	146	146	146	146
Transportation	Electricity	0	3,002	3,494	4,388	5,616	6,487	7,288	8,196	9,421	10,769
	Gasoline	2,366,884	2,437,538	2,484,255	2,477,392	2,467,341	2,451,391	2,431,245	2,409,554	2,390,231	2,373,746
	Diesel	594,989	599,914	607,070	602,253	600,071	596,396	590,475	584,429	578,018	571,617
Solid Waste	Non Energy	40,038	40,038	40,039	40,040	40,041	40,041	40,042	40,043	40,044	40,044
Wastewater	Non Energy	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936
Agriculture	Non Energy	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621
Urban Forest	Non Energy	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430
Total		*11,037,331*	*10,514,259*	*10,263,757*	*10,246,837*	*10,447,366*	*10,317,393*	*10,157,563*	*10,078,373*	*10,146,111*	*10,232,260*

Sector	Emissions - MT CO2e	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Residential	Electricity	1,560,803	1,590,107	1,613,338	1,634,470	1,624,290	1,609,729	1,595,719	1,572,808	1,554,667	1,535,187
	Natural Gas	950,376	939,913	929,422	919,709	910,971	902,535	893,952	885,439	877,166	869,237
Commercial	Electricity	1,304,912	1,327,130	1,344,704	1,360,772	1,350,599	1,336,650	1,322,683	1,301,850	1,284,464	1,266,057
	Natural Gas	711,993	708,452	704,430	701,112	698,674	696,147	692,914	689,326	685,654	682,004
Industrial	Electricity	1,234,052	1,260,856	1,280,181	1,295,814	1,286,615	1,273,718	1,263,177	1,244,457	1,228,541	1,211,320
	Natural Gas	662,662	661,841	658,603	655,743	655,087	653,377	652,612	652,756	651,901	651,840
	Other	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203
Electricity Generation	Other	146	146	146	146	146	146	146	146	146	146
Transportation	Electricity	12,000	13,295	14,559	15,814	16,740	17,593	18,416	19,104	19,817	20,498
	Gasoline	2,344,027	2,313,528	2,287,647	2,262,966	2,238,260	2,215,474	2,195,682	2,177,221	2,161,104	2,146,550
	Diesel	560,606	550,942	542,112	533,044	524,834	516,889	510,357	504,396	498,214	492,730
Solid Waste	Non Energy	40,045	40,046	40,047	40,047	40,048	40,049	40,050	40,050	40,051	40,052
Wastewater	Non Energy	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936
Agriculture	Non Energy	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621
Urban Forest	Non Energy	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430
Total		*10,288,717*	*10,372,144*	*10,439,834*	*10,503,039*	*10,485,047*	*10,455,049*	*10,431,499*	*10,384,080*	*10,348,660*	*10,311,911*

Sector	Emissions - MT CO2e	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Residential	Electricity	1,520,379	1,506,103	1,497,332	1,484,762	1,479,701	1,466,929	1,456,457	1,454,185	1,442,124	1,429,076
	Natural Gas	861,503	853,919	846,423	839,435	832,324	825,167	817,950	810,733	803,444	796,131
Commercial	Electricity	1,253,565	1,241,832	1,234,695	1,223,687	1,219,151	1,206,781	1,197,314	1,193,948	1,183,087	1,171,104
	Natural Gas	678,539	675,210	671,881	668,996	665,995	662,834	659,513	656,149	652,628	649,005
Industrial	Electricity	1,200,933	1,191,721	1,185,095	1,172,985	1,167,142	1,155,413	1,142,719	1,134,238	1,119,917	1,108,347
	Natural Gas	653,393	656,489	660,453	660,996	665,423	667,394	667,042	667,981	669,139	673,475
	Other	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203	569,203
Electricity Generation	Other	146	146	146	146	146	146	146	146	146	146
Transportation	Electricity	21,205	21,868	22,583	23,217	23,919	24,472	25,028	25,681	26,135	26,542
	Gasoline	2,133,020	2,120,798	2,109,356	2,099,341	2,090,879	2,084,530	2,078,090	2,071,868	2,067,510	2,065,279
	Diesel	487,534	483,460	479,580	475,384	471,138	467,406	462,946	457,830	453,689	450,550
Solid Waste	Non Energy	40,053	40,053	40,054	40,055	40,056	40,057	40,057	40,058	40,059	40,060
Wastewater	Non Energy	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936	310,936
Agriculture	Non Energy	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621	110,621
Urban Forest	Non Energy	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430	-112,430
Total		*10,296,153*	*10,286,413*	*10,291,943*	*10,281,039*	*10,297,149*	*10,288,776*	*10,280,904*	*10,294,210*	*10,283,456*	*10,279,121*

8 Appendix 2. Local Greenhouse Gas Inventory Tool