Appendix M

Greenhouse Gas Emissions Summary

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Iron Pine Solar Project
GHG Emissions Summary

		Annual Emissions (short ton/yr)[1]				Total Project Emissions (short tons)			
Project	**Source**	**CO_2 (ton/yr)**	**CH_4 (ton/yr)**	**N_2O (ton/yr)**	**CO_2e (ton/yr)**	**CO_2 (ton)**	**CH_4 (ton)**	**N_2O (ton)**	**CO_2e (ton)**
Construction Emissions									
Solar Project	Construction - Mobile Sources Onroad - Gasoline and Diesel	177	5.47E-03	5.13E-03	179	310	9.58E-03	8.98E-03	313
Solar Project	Construction - Mobile Sources Non-road - Diesel	6,599	6.54E-01	6.09E-01	6,797	11,549	1.14E+00	1.06E+00	11,895
Gen-Tie Project	Construction - Mobile Sources Onroad - Gasoline and Diesel	31	2.17E-04	9.86E-04	31	53	3.80E-04	1.73E-03	54
Gen-Tie Project	Construction - Mobile Sources Non-road - Diesel	1,775	1.76E-01	1.64E-01	1,829	3,107	3.08E-01	2.86E-01	3,200
Total Construction Emissions		**8,583**	**8.35E-01**	**7.78E-01**	**8,835**	**15,020**	**1.46E+00**	**1.36E+00**	**15,462**
Operational Emissions									
Solar Project	Operations - Mobile Sources	3.2	5.96E-05	4.30E-05	3.2	95.4	1.79E-03	1.29E-03	96
Total Operational Emissions		**3.2**	**5.96E-05**	**4.30E-05**	**3.2**	**95.4**	**1.79E-03**	**1.29E-03**	**96**
Decomissioning Emissions									
Solar Project	Decomissioning - Mobile Sources Onroad - Gasoline and Diesel[2]	177	5.47E-03	5.13E-03	179	177	5.47E-03	5.13E-03	179
Solar Project	Decomissioning - Mobile Sources Non-road - Diesel[2]	6599	6.54E-01	6.09E-01	6797	6599	6.54E-01	6.09E-01	6797
Total Decomissioning Emissions		**6,777**	**6.59E-01**	**6.14E-01**	**6,976**	**6,777**	**6.59E-01**	**6.14E-01**	**6,976**
Total Lifetime Emissions						**21,892**	**2.12E+00**	**1.98E+00**	**22,534**
Avoided Emissions									
Scope 2	Electricity Generation Avoided Emissions[3]				-308,000				-9,240,000
Total - Net Emissions Change						**21,892**	**2**	**2**	**-9,217,466**

1. Construction and decomissioning emissions will take place for short duration at the beginning and end of the solar project, respectively.

2. Assume decomissioning will require the same equipment and number of workers as construction. Per the application, decomissioning is expected to take place within 1 year of solar plant closure.

3. Avoided emissions are consistent with Section 1.1., that the electricity generated by the project will offset approximately 280,000 metric tons (or 308,000 short tons) of CO2e annually.

Construction - Solar Project Mobile Sources

Construction Project	1.75	Years (estimate)
Lifetime	30	Years (estimate, based on RPA application)

								Annual		Total for Project	
Onroad/Off-Road	Vehicle Type[1]	Number of Vehicles per Day[2]	Fuel Type	VMT (miles per day, per vehicle)[3]	Miles per Gallon[4]	Fuel Usage (gal/day, all vehicles)	Days Per Year[2]	Miles Traveled (mi/yr, all vehicles)	Fuel Usage (gal/yr, all vehicles)	Miles Traveled (mi)	Fuel Usage (gal)
Onroad	Light Duty Vehicles - Laborers (commute)	25	Gas	20	22.8	22.0	260	130,000	5,710	227,500	9,992
	Light Duty Vehicles - Laborers (commute)	25	Diesel	20	18.1	27.7	260	130,000	7,202	227,500	12,603
	Heavy Duty Trucks - Dump Trucks (onsite and offsite)	5	Diesel	20	7.9	12.6	200	20,000	2,522	35,000	4,414
	Heavy Duty Trucks - Semis (onsite and offsite)	8	Diesel	20	6.9	23.1	50	8,000	1,157	14,000	2,025

1. Vehicle types are defined by the Federal Highway Administration (FHWA). Assumed for this project that all commuters used light duty vehicles.

2. Laborers commute data provided by facility: Approximate 300+ people working onsite at maximum construction capacity. Assuming some people carpool, average number of vehicles per day estimated at

3. Based on estimate from the facility.

4. For light duty vehicles, based on 2022 value from U.S. Department of Transportation, Federal Highway Administration, Highway Statistics (Washington, DC: Annual Issues), Table VM-1, available at http://
from Table VM-1.

5. Emission factors based on the U.S. EPA's Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub, updated April 2022). Assume Year 2007 for CH4, N2O emission factor

									Emission Factors[3]		
Onroad/Offroad	Vehicle Type	Number of Vehicles[1]	Fuel type	Engine Size (hp)[1]	Consumption Rate (gal/hour per hp-hr)[2]	Hours per Year[1]	Total Gallons per Year	Total Gallons for Project	CO2 (kg/gal)	CH4 (g/gal)	N2O (g/gal)
Off-road	Crane	0	Diesel	-	0.05	2,080	0	0	10.21	1.01	0.94
	Backhoe	0	Diesel	-	0.05	2,080	0	0	10.21	1.01	0.94
	Loader	4	Diesel	350	0.05	2,080	145,600	254,800	10.21	1.01	0.94
	Bulldozer	5	Diesel	350	0.05	2,080	182,000	318,500	10.21	1.01	0.94
	Excavator	5	Diesel	400	0.05	2,080	208,000	364,000	10.21	1.01	0.94
	Skid Steer	5	Diesel	100	0.05	2,080	52,000	91,000	10.21	1.01	0.94
	Total	19					587,600	1,028,300			Total

1. Estimated based on information from similar projects.

2. Off-road mobile source fuel usage based on South Coast Air Quality Management District CEQA Air Quality Handbook, Table A9-3E.

3. Emission factors based on the U.S. EPA's Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub, updated April 2022).

Construction - Solar Project Mobile Sources

Construction	1.75 Years (estimat
Project Lifetime	30 Years (estimat

			Emission Factors[5]			Total Emissions (ton)				Emissions per Year			
Onroad/Off-Road	Vehicle Type[1]	Number of Vehicles per Day[2]	CO2 (kg/gal)	CH4 (g/mile)	N2O (g/mile)	CO2 (short ton)	CH4 (short ton)	N2O (short ton)	CO2e (short ton)	CO2 (short ton/yr)	CH4 (short ton/yr)	N2O (short ton/yr)	CO2e (short ton/yr)
Onroad	Light Duty Vehicles - Laborers (commute)	25	8.78	0.0072	0.0052	96.51	0.0018	0.00130	97	55.1	0.00103	0.00075	55.395
	Light Duty Vehicles - Laborers (commute)	25	10.21	0.029	0.0214	141.54	0.0073	0.00536	143	80.9	0.00415	0.00306	81.897
	Heavy Duty Trucks - Dump Trucks (onsite and offsite)	5	10.21	0.0095	0.0431	49.58	0.0004	0.0017	50	28.3	0.00021	0.0009	28.617
	Heavy Duty Trucks - Semis (onsite and offsite)	8	10.21	0.0095	0.0431	22.75	0.0001	0.0007	23	13.0	0.00008	0.0004	13.114
					Total	**310**	**0.010**	**0.009**	**313**	**177.4**	**0.00547**	**0.0051**	**179.0**

1. Vehicle types are defined by the Federal Highway Adm

2. Laborers commute data provided by facility: Approxima 50. Assume half of the vehicles will be gas, half will be diesel.

3. Based on estimate from the facility.

4. For light duty vehicles, based on 2022 value from U.S. /www.fhwa.dot.gov/policyinformation/statistics.cfm as of February 2022. For heavy duty vehicles, used value for "Single Unit Trucks" for Dump Trucks and "Combination Trucks" for Semis from Table VM-1.

5. Emission factors based on the U.S. EPA's Emission Fs.

			Total Project Emissions				Emissions Per Year			
Onroad/Offroad	Vehicle Type	Number of Vehicles[1]	CO2 (short ton)	CH4 (short ton)	N2O (short ton)	CO2e (short ton)	CO2 (short ton/yr)	CH4 (short ton/yr)	N2O (short ton/yr)	CO2e (short ton/yr)
Off-road	Crane	0	0.00	0.000	0.000	-	-	-	-	-
	Backhoe	0	0.00	0.000	0.000	-	-	-	-	-
	Loader	4	2861.66	0.284	0.264	2,947	1,635.2	0.1620	0.1508	1,684.2
	Bulldozer	5	3577.07	0.354	0.330	3,684	2,044.0	0.2025	0.1885	2,105.3
	Excavator	5	4088.08	0.405	0.377	4,211	2,336.0	0.2315	0.2154	2,406.0
	Skid Steer	5	1022.02	0.101	0.094	1,053	584.0	0.0579	0.0538	601.5
	Total	19	**11,549**	**1.144**	**1.065**	**11,895**	**6,599.3**	**0.65388**	**0.6085**	**6,797.0**

1. Estimated based on information from similar projects.

2. Off-road mobile source fuel usage based on South Coa

3. Emission factors based on the U.S. EPA's Emission Fa

Construction - Gen Tie Line Project Mobile Sources

Construction Project	1.75	Years (estimate)
Lifetime	30	Years (estimate)

								Annual		Total for Project	
Onroad/Off-Road	Vehicle Type[1]	Number of Vehicles per Day[2]	Fuel Type	VMT (miles per day, per vehicle)[3]	Miles per Gallon[4]	Fuel Usage (gal/day, all vehicles)	Days Per Year[5]	Miles Traveled (mi/yr, all vehicles)	Fuel Usage (gal/yr, all vehicles)	Miles Traveled (mi)	Fuel Usage (gal)
Onroad	Light Duty Vehicles - Laborers (commute - already counted in solar project calcs)	0	Gas	20	22.8	0.0	260	0	0	0	0
	Heavy Duty Trucks - Dump Trucks (onsite and offsite)	3	Diesel	20	7.9	7.6	260	15,600	1,968	27,300	3,443
	Heavy Duty Trucks - Semis (onsite and offsite)	1	Diesel	20	6.9	2.9	260	5,200	752	9,100	1,317

1. Vehicle types are defined by the Federal Highway Administration (FHWA). Assumed for this project that all commuters used light duty vehicles.

2. Estimate based on other similar projects

3. Based on estimate from the facility.

4. For light duty vehicles, based on 2022 value from U.S. Department of Transportation, Federal Highway Administration, Highway Statistics (Washington, DC: Annual Issues), Table VM-1, available at http://w

5. Assumes 5 days/week, 52 weeks/year.

6. Emission factors based on the U.S. EPA's Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub, updated April 2022).

									Emission Factors[4]		
Onroad/Offroad	Vehicle Type	Number of Vehicles[1]	Fuel type	Engine Size (hp)[1]	Consumption Rate (gal/hour per hp-hr)[2]	Hours per Year[3]	Total Gallons per Year	Total Gallons for Project	CO2 (kg/gal)	CH4 (g/gal)	N2O (g/gal)
Off-road	Crane	1	Diesel	320	0.05	2,080	33,280	58,240	10.21	1.01	0.94
	Backhoe	1	Diesel	100	0.05	2,080	10,400	18,200	10.21	1.01	0.94
	Loader	1	Diesel	400	0.05	2,080	41,600	72,800	10.21	1.01	0.94
	Bulldozer	1	Diesel	200	0.05	2,080	20,800	36,400	10.21	1.01	0.94
	Excavator	1	Diesel	300	0.05	2,080	31,200	54,600	10.21	1.01	0.94
	Skid Steer	2	Diesel	100	0.05	2,080	20,800	36,400	10.21	1.01	0.94
	Total	7					158,080	276,640			Total

1. Estimated based on information from similar projects.

2. Off-road mobile source fuel usage based on South Coast Air Quality Management District CEQA Air Quality Handbook, Table A9-3E.

3. Based on 5 days/week, 52 weeks/year.

4. Emission factors based on the U.S. EPA's Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub, updated April 2022).

Construction - Gen Tie Line Project Mobile Sources

Construction	1.75 Years (estimat
Project Lifetime	30 Years (estimat

			Emission Factors[6]			Total Emissions (ton)				Emissions per Year			
Onroad/Off-Road	**Vehicle Type[1]**	**Number of Vehicles per Day[2]**	**CO2 (kg/gal)**	**CH4 (g/mile)**	**N2O (g/mile)**	**CO2 (short ton)**	**CH4 (short ton)**	**N2O (short ton)**	**CO2e (short ton)**	**CO2 (short ton/yr)**	**CH4 (short ton/yr)**	**N2O (short ton/yr)**	**CO2e (short ton/yr)**
Onroad	Light Duty Vehicles - Laborers (commute - already counted in solar project calcs)	0	8.78	0.007226	0.005213	-	0.0000	0.00000	-	-	-	-	-
	Heavy Duty Trucks - Dump Trucks (onsite and offsite)	3	10.21	0.0095	0.0431	38.67	0.0003	0.0013	39	22.1	0.00016	0.0007	22.322
	Heavy Duty Trucks - Semis (onsite and offsite)	1	10.21	0.0095	0.0431	14.79	0.0001	0.0004	15	8.4	0.00005	0.0002	8.524
					Total	**53**	**0.000**	**0.002**	**54**	**30.5**	**0.00022**	**0.0010**	**30.8**

1. Vehicle types are defined by the Federal Highway Admi

2. Estimate based on other similar projects

3. Based on estimate from the facility.

4. For light duty vehicles, based on 2022 value from U.S. ww.fhwa.dot.gov/policyinformation/statistics.cfm as of February 2022. For heavy duty vehicles, used value for "Single Unit Trucks" for Dump Trucks and "Combination Trucks" for Semis from Table VM-1.

5. Assumes 5 days/week, 52 weeks/year.

6. Emission factors based on the U.S. EPA's Emission Fa

			Total Project Emissions				Emissions Per Year			
Onroad/Offroad	**Vehicle Type**	**Number of Vehicles[1]**	**CO2 (short ton)**	**CH4 (short ton)**	**N2O (short ton)**	**CO2e (short ton)**	**CO2 (short ton/yr)**	**CH4 (short ton/yr)**	**N2O (short ton/yr)**	**CO2e (short ton/yr)**
Off-road	Crane	1	654.09	0.065	0.060	674	373.8	0.0370	0.0345	385.0
	Backhoe	1	204.40	0.020	0.019	211	116.8	0.0116	0.0108	120.3
	Loader	1	817.62	0.081	0.075	842	467.2	0.0463	0.0431	481.2
	Bulldozer	1	408.81	0.041	0.038	421	233.6	0.0231	0.0215	240.6
	Excavator	1	613.21	0.061	0.057	632	350.4	0.0347	0.0323	360.9
	Skid Steer	2	408.81	0.041	0.038	421	233.6	0.0231	0.0215	240.6
	Total	7	**3,107**	**0.308**	**0.286**	**3,200**	**1,775.4**	**0.17591**	**0.1637**	**1,828.6**

1. Estimated based on information from similar projects.

2. Off-road mobile source fuel usage based on South Coa

3. Based on 5 days/week, 52 weeks/year.

4. Emission factors based on the U.S. EPA's Emission Fa

Operation - Mobile Sources

Project Lifetime 30 Years (estimate)

								Annual		Total for Project		Emission Factors[4]		
Onroad/Off-Road	Vehicle Type[1]	Number of Vehicles per Day[2]	Fuel Type	VMT (miles per day, per vehicle)[2]	Miles per Gallon[3]	Fuel Usage (gal/day, all vehicles)	Days Per Year[2]	Miles Traveled (mi/yr, all vehicles)	Fuel Usage (gal/yr, all vehicles)	Miles Traveled (mi)	Fuel Usage (gal)	CO2 (kg/gal)	CH4 (g/mile)	N2O (g/mile)
Onroad	Light Duty Vehicles	3	Gas	10	22.8	1.32	250	7,500	329	225,000	9,883	8.78	0.0072	0.0052
														Total

1. Vehicle types are defined by the Federal Highway Administration (FHWA). Assumed operation performed using light duty vehicles.

2. Per facility - approximately 2-3 vehicles daily, traveling approximately 10 miles per day per vehicle. Days per year is based on 50 weeks/year and 5 days/week.

3. For light duty vehicles, based on 2022 value from U.S. Department of Transportation, Federal Highway Administration, Highway Statistics (Washington, DC: Annual Issues), Table VM-1, available at http://www.fhwa.dot.gov/policyinformation/statistics.cfm Semis from Table VM-1.

4. Emission factors based on the U.S. EPA's Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub, updated April 2022).

Operation - Mobile Sources

Project Lifetime 30 Years (estimat

Onroad/Off-Road	Vehicle Type[1]	Number of Vehicles per Day[2]	Total Emissions (ton) CO2 (short ton)	CH4 (short ton)	N2O (short ton)	CO2e (short ton)	Annual Emissions (ton/yr) CO2 (short ton/yr)	CH4 (short ton/yr)	N2O (short ton/yr)	CO2e (short ton/yr)
Onroad	Light Duty Vehicles	3	95.45	0.0018	0.00129	96	3.2	0.00006	0.00004	3.2
			95	**0.002**	**0.001**	**96**	**3.2**	**0.00006**	**0.0000**	**3.2**

1. Vehicle types are defined by the Federal Highway Adm

2. Per facility - approximately 2-3 vehicles daily, traveling

3. For light duty vehicles, based on 2022 value from U.S. as of February 2022. For heavy duty vehicles, used value for "Single Unit Trucks" for Dump Trucks and "Combination Trucks" for Semis from Table VM-1.

4. Emission factors based on the U.S. EPA's Emission Fa

Decommissioning Solar Project - Mobile Sources

Decomissioning Duration 1.00 Years (based on RPA application)

								Annual		Total for Project	
Onroad/Off-Road	Vehicle Type[1]	Number of Vehicles per Day[2]	Fuel Type	VMT (miles per day, per vehicle)[3]	Miles per Gallon[4]	Fuel Usage (gal/day, all vehicles)	Days Per Year[2]	Miles Traveled (mi/yr, all vehicles)	Fuel Usage (gal/yr, all vehicles)	Miles Traveled (mi)	Fuel Usage (gal)
Onroad	Light Duty Vehicles - Laborers (commute)	25	Gas	20	22.8	22.0	260	130,000	5,710	130,000	5,710
	Light Duty Vehicles - Laborers (commute)	25	Diesel	20	18.1	27.7	260	130,000	7,202	130,000	7,202
	Heavy Duty Trucks - Dump Trucks (onsite and offsite)	5	Diesel	20	7.9	12.6	200	20,000	2,522	20,000	2,522
	Heavy Duty Trucks - Semis (onsite and offsite)	8	Diesel	20	6.9	23.1	50	8,000	1,157	8,000	1,157

1. Vehicle types are defined by the Federal Highway Administration (FHWA). Assumed for this project that all commuters used light duty vehicles.

2. Laborers commute data provided by facility: Approximate 300+ people working onsite at maximum construction capacity. Assuming some people carpool, average number of vehicles per day estimated at 50

3. Based on estimate from the facility.

4. For light duty vehicles, based on 2022 value from U.S. Department of Transportation, Federal Highway Administration, Highway Statistics (Washington, DC: Annual Issues), Table VM-1, available at http://ww from Table VM-1.

5. Emission factors based on the U.S. EPA's Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub, updated April 2022).

									Emission Factors[3]		
Onroad/Offroad	Vehicle Type	Number of Vehicles[1]	Fuel type	Engine Size (hp)[1]	Consumption Rate (gal/hour per hp-hr)[2]	Hours per Year[1]	Total Gallons per Year	Total Gallons for Project	CO2 (kg/gal)	CH4 (g/gal)	N2O (g/gal)
Off-road	Crane	0	Diesel	250	0.05	2,080	0	0	10.21	1.01	0.94
	Backhoe	0	Diesel	-	0.05	2,080	0	0	10.21	1.01	0.94
	Loader	4	Diesel	350	0.05	2,080	145,600	145,600	10.21	1.01	0.94
	Bulldozer	5	Diesel	350	0.05	2,080	182,000	182,000	10.21	1.01	0.94
	Excavator	5	Diesel	400	0.05	2,080	208,000	208,000	10.21	1.01	0.94
	Skid Steer	5	Diesel	100	0.05	2,080	52,000	52,000	10.21	1.01	0.94
	Total	19					587,600	587,600			Total

1. Estimated based on information from similar projects.

2. Off-road mobile source fuel usage based on South Coast Air Quality Management District CEQA Air Quality Handbook, Table A9-3E.

3. Emission factors based on the U.S. EPA's Emission Factors Hub (https://www.epa.gov/climateleadership/ghg-emission-factors-hub, updated April 2022).

Decommissioning Solar Project - Mobile Sources

Decomissioning Duration 1.00 Years (based

			Emission Factors[5]			Total Emissions (ton)				Emissions per Year			
Onroad/Off-Road	**Vehicle Type[1]**	**Number of Vehicles per Day[2]**	**CO2 (kg/gal)**	**CH4 (g/mile)**	**N2O (g/mile)**	**CO2 (short ton)**	**CH4 (short ton)**	**N2O (short ton)**	**CO2e (short ton)**	**CO2 (short ton/yr)**	**CH4 (short ton/yr)**	**N2O (short ton/yr)**	**CO2e (short ton/yr)**
Onroad	Light Duty Vehicles - Laborers (commute)	25	8.78	0.007226	0.005213	55.15	0.0010	0.00075	55	55.1	0.00103	0.00075	55.395
	Light Duty Vehicles - Laborers (commute)	25	10.21	0.029	0.0214	80.88	0.0041	0.00306	82	80.9	0.00415	0.00306	81.897
	Heavy Duty Trucks - Dump Trucks (onsite and offsite)	5	10.21	0.0095	0.0431	28.33	0.0002	0.0009	29	28.3	0.00021	0.0009	28.617
	Heavy Duty Trucks - Semis (onsite and offsite)	8	10.21	0.0095	0.0431	13.00	0.0001	0.0004	13	13.0	0.00008	0.0004	13.114
					Total	**177**	**0.005**	**0.005**	**179**	**177.4**	**0.00547**	**0.0051**	**179.0**

1. Vehicle types are defined by the Federal Highway Adminis

2. Laborers commute data provided by facility: Approximate 3 Assume half of the vehicles will be gas, half will be diesel.

3. Based on estimate from the facility.

4. For light duty vehicles, based on 2022 value from U.S. De ww.fhwa.dot.gov/policyinformation/statistics.cfm as of February 2022. For heavy duty vehicles, used value for "Single Unit Trucks" for Dump Trucks and "Combination Trucks" for Semis from Table VM-1.

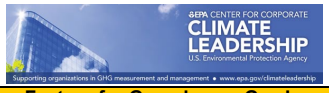
5. Emission factors based on the U.S. EPA's Emission Facto

			Total Project Emissions				Emissions Per Year			
Onroad/Offroad	**Vehicle Type**	**Number of Vehicles[1]**	**CO2 (short ton)**	**CH4 (short ton)**	**N2O (short ton)**	**CO2e (short ton)**	**CO2 (short ton/yr)**	**CH4 (short ton/yr)**	**N2O (short ton/yr)**	**CO2e (short ton/yr)**
Off-road	Crane	0	0.00	0.000	0.000	-	-	-	-	-
	Backhoe	0	0.00	0.000	0.000	-	-	-	-	-
	Loader	4	1635.23	0.162	0.151	1,684	1,635.2	0.1620	0.1508	1,684.2
	Bulldozer	5	2044.04	0.203	0.188	2,105	2,044.0	0.2025	0.1885	2,105.3
	Excavator	5	2336.05	0.231	0.215	2,406	2,336.0	0.2315	0.2154	2,406.0
	Skid Steer	5	584.01	0.058	0.054	602	584.0	0.0579	0.0538	601.5
	Total	19	**6,599**	**0.654**	**0.609**	**6,797**	**6,599.3**	**0.65388**	**0.6085**	**6,797.0**

1. Estimated based on information from similar projects.

2. Off-road mobile source fuel usage based on South Coast A

3. Emission factors based on the U.S. EPA's Emission Facto



Emission Factors for Greenhouse Gas Inventories

Last Modified: February 13, 2024

Blue text indicates an update from the 2023 version of this document.

Typically, greenhouse gas emissions are reported in units of carbon dioxide equivalent (CO_2e). Gases are converted to CO_2e by multiplying by their global warming potential (GWP). In most cases, the emission factors listed in this document generally have not been converted to CO_2e. To do so, multiply the emissions by the corresponding GWP listed in the table below.

Gas	100-Year GWP
CH_4	28
N_2O	265

Source: Intergovernmental Panel on Climate Change (IPCC), Fifth Assessment Report (AR5), 2013. See the source note to Table 11 for further explanation.

Notes:
These GWP values represent a change from the previous version of this document. In alignment with the U.S. Inventory of U.S. GHG Emissions and Sinks 1990-2021 Inventory Report, the recommended GWP values have been updated to Intergovernmental Panel on Climate Change (IPCC), Fifth Assessment Report (AR5) values.

Table 1 Stationary Combustion

Fuel Type	Heat Content (HHV)	CO_2 Factor	CH_4 Factor	N_2O Factor	CO_2 Factor	CH_4 Factor	N_2O Factor	
	mmBtu per short ton	kg CO_2 per mmBtu	g CH_4 per mmBtu	g N_2O per mmBtu	kg CO_2 per short ton	g CH_4 per short ton	g N_2O per short	
Coal and Coke								
Anthracite	25.09	103.69	11	1.6	2,602	276	40	
Bituminous	24.93	93.28	11	1.6	2,325	274	40	
Sub-bituminous	17.25	97.17	11	1.6	1,676	190	28	
Lignite	14.21	97.72	11	1.6	1,389	156	23	
Mixed (Commercial Sector)	21.39	94.27	11	1.6	2,016	235	34	
Mixed (Electric Power Sector)	19.73	95.52	11	1.6	1,885	217	32	
Mixed (Industrial Coking)	26.28	93.90	11	1.6	2,468	289	42	
Mixed (Industrial Sector)	22.35	94.67	11	1.6	2,116	246	36	
Coal Coke	24.80	113.67	11	1.6	2,819	273	40	
Other Fuels - Solid								
Municipal Solid Waste	9.95	90.70	32	4.2	902	318	42	
Petroleum Coke (Solid)	30.00	102.41	32	4.2	3,072	960	126	
Plastics	38.00	75.00	32	4.2	2,850	1,216	160	
Tires	28.00	85.97	32	4.2	2,407	896	118	
Biomass Fuels - Solid								
Agricultural Byproducts	8.25	118.17	32	4.2	975	264	35	
Peat	8.00	111.84	32	4.2	895	256	34	
Solid Byproducts	10.39	105.51	32	4.2	1,096	332	44	
Wood and Wood Residuals	17.48	93.80	7.2	3.6	1,640	126	63	
	mmBtu per scf	kg CO_2 per mmBtu	g CH_4 per mmBtu	g N_2O per mmBtu	kg CO_2 per scf	g CH_4 per scf	g N_2O per scf	
Natural Gas								
Natural Gas	0.001026	53.06	1.0	0.10	0.05444	0.00103	0.00010	0.0530600 tCO2e/mmBtu
Other Fuels - Gaseous								
Blast Furnace Gas	0.000092	274.32	0.022	0.10	0.02524	0.000002	0.000009	
Coke Oven Gas	0.000599	46.85	0.48	0.10	0.02806	0.000288	0.000060	
Fuel Gas	0.001388	59.00	3.0	0.60	0.08189	0.004164	0.000833	
Propane Gas	0.002516	61.46	3.0	0.60	0.15463	0.007548	0.001510	
Biomass Fuels - Gaseous								
Landfill Gas	0.000485	52.07	3.2	0.63	0.025254	0.001552	0.000306	
Other Biomass Gases	0.000655	52.07	3.2	0.63	0.034106	0.002096	0.000413	
	mmBtu per gallon	kg CO_2 per mmBtu	g CH_4 per mmBtu	g N_2O per mmBtu	kg CO_2 per gallon	g CH_4 per gallon	g N_2O per gallon	
Petroleum Products								
Asphalt and Road Oil	0.158	75.36	3.0	0.60	11.91	0.47	0.09	
Aviation Gasoline	0.120	69.25	3.0	0.60	8.31	0.36	0.07	
Butane	0.103	64.77	3.0	0.60	6.67	0.31	0.06	
Butylene	0.105	68.72	3.0	0.60	7.22	0.32	0.06	
Crude Oil	0.138	74.54	3.0	0.60	10.29	0.41	0.08	
Distillate Fuel Oil No. 1	0.139	73.25	3.0	0.60	10.18	0.42	0.08	
Distillate Fuel Oil No. 2	0.138	73.96	3.0	0.60	10.21	0.41	0.08	0.0739600 tCO2e/mmBtu
Distillate Fuel Oil No. 4	0.146	75.04	3.0	0.60	10.96	0.44	0.09	
Ethane	0.068	59.60	3.0	0.60	4.05	0.20	0.04	
Ethylene	0.058	65.96	3.0	0.60	3.83	0.17	0.03	
Heavy Gas Oils	0.148	74.92	3.0	0.60	11.09	0.44	0.09	
Isobutane	0.099	64.94	3.0	0.60	6.43	0.30	0.06	
Isobutylene	0.103	68.86	3.0	0.60	7.09	0.31	0.06	
Kerosene	0.135	75.20	3.0	0.60	10.15	0.41	0.08	
Kerosene-Type Jet Fuel	0.135	72.22	3.0	0.60	9.75	0.41	0.08	
Liquefied Petroleum Gases (LPG)	0.092	61.71	3.0	0.60	5.68	0.28	0.06	
Lubricants	0.144	74.27	3.0	0.60	10.69	0.43	0.09	
Motor Gasoline	0.125	70.22	3.0	0.60	8.78	0.38	0.08	
Naphtha (<401 deg F)	0.125	68.02	3.0	0.60	8.50	0.38	0.08	
Natural Gasoline	0.110	66.88	3.0	0.60	7.36	0.33	0.07	
Other Oil (>401 deg F)	0.139	76.22	3.0	0.60	10.59	0.42	0.08	
Pentanes Plus	0.110	70.02	3.0	0.60	7.70	0.33	0.07	
Petrochemical Feedstocks	0.125	71.02	3.0	0.60	8.88	0.38	0.08	
Propane	0.091	62.87	3.0	0.60	5.72	0.27	0.05	
Propylene	0.091	67.77	3.0	0.60	6.17	0.27	0.05	
Residual Fuel Oil No. 5	0.140	72.93	3.0	0.60	10.21	0.42	0.08	
Residual Fuel Oil No. 6	0.150	75.10	3.0	0.60	11.27	0.45	0.09	
Special Naphtha	0.125	72.34	3.0	0.60	9.04	0.38	0.08	
Unfinished Oils	0.139	74.54	3.0	0.60	10.36	0.42	0.08	
Used Oil	0.138	74.00	3.0	0.60	10.21	0.41	0.08	
Biomass Fuels - Liquid								
Biodiesel (100%)	0.128	73.84	1.1	0.11	9.45	0.14	0.01	
Ethanol (100%)	0.084	68.44	1.1	0.11	5.75	0.09	0.01	
Rendered Animal Fat	0.125	71.06	1.1	0.11	8.88	0.14	0.01	
Vegetable Oil	0.120	81.55	1.1	0.11	9.79	0.13	0.01	
Biomass Fuels - Kraft Pulping Liquor, by Wood Furnish								
North American Softwood		94.4	1.9	0.42				
North American Hardwood		93.7	1.9	0.42				
Bagasse		95.5	1.9	0.42				
Bamboo		93.7	1.9	0.42				
Straw		95.1	1.9	0.42				

Source:
Federal Register EPA; 40 CFR Part 98; e-CFR, (see link below). Table C-1 and Table C-2 (78 FR 71950, Nov. 29, 2013, as amended at 81 FR 89252, Dec. 9, 2016), Table AA-1 (78 FR 71965, Nov. 29, 2013).
https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-98

Notes:
Emission factors are per unit of heat content using higher heating values (HHV). If heat content is available from the fuel supplier, it is preferable to use that value. If not, default heat contents are provided.
All CO_2 emission factors assume that 100 percent of the carbon content of the fuel is oxidized to CO_2, as is recommended by the Intergovernmental Panel on Climate Change (IPCC).
The CH_4 and N_2O emission factors provided represent emissions in terms of fuel type and by end-use sector (i.e., residential, commercial, industrial, electricity generation).
The factors represented in the table above represent combustion emissions only and do not represent upstream emissions.

Table 2 Mobile Combustion CO_2

Fuel Type	kg CO_2 per unit	Unit
Aviation Gasoline	8.31	gallon
Biodiesel (100%)	9.45	gallon
Compressed Natural Gas (CNG)	0.05444	scf
Diesel Fuel	10.21	gallon
Ethanol (100%)	5.75	gallon
Kerosene-Type Jet Fuel	9.75	gallon
Liquefied Natural Gas (LNG)	4.50	gallon
Liquefied Petroleum Gases (LPG)	5.68	gallon
Motor Gasoline	8.78	gallon
Residual Fuel Oil	11.27	gallon

Source:
Federal Register EPA; 40 CFR Part 98; e-CFR, (see link below). Table C-1 (78 FR 71950, Nov. 29, 2013, as amended at 81 FR 89252, Dec. 9, 2016)
https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-98

Notes:
LNG: The factor was developed based on the CO_2 factor (kg CO2 per mmBtu) for Natural Gas from Table 1 and the higher heating value (HHV) LNG fuel density factor (btu/gallon) from the GREET1 2023 Model, Argonne National Laboratory published December 21, 2023 (Fuel_Specs worksheet).
More information on GREET can be found here: https://greet.anl.gov/greet_excel_model.models
The factors represented in the table above represent combustion emissions only (tank-to-wheel) and do not represent upstream emissions or well-to-wheel emissions.

Table 3 Mobile Combustion CH_4 and N_2O for On-Road Gasoline Vehicles

Vehicle Type	Model Year	CH_4 Factor (g CH_4 / vehicle-mile)	N_2O Factor (g N_2O / vehicle-mile)
Gasoline Passenger Cars	1973-1974	0.1696	0.0197
	1975	0.1423	0.0443
	1976-1977	0.1406	0.0458
	1978-1979	0.1389	0.0473
	1980	0.1326	0.0499
	1981	0.0802	0.0626
	1982	0.0795	0.0627
	1983	0.0782	0.0630
	1984-1993	0.0704	0.0647
	1994	0.0617	0.0603
	1995	0.0531	0.0560
	1996	0.0434	0.0503
	1997	0.0337	0.0446
	1998	0.0240	0.0389
	1999	0.0215	0.0355
	2000	0.0175	0.0304
	2001	0.0105	0.0212
	2002	0.0102	0.0207
	2003	0.0095	0.0181
	2004	0.0078	0.0085
	2005	0.0075	0.0067
	2006	0.0076	0.0075
	2007	0.0072	0.0052
	2008	0.0072	0.0049
	2009	0.0071	0.0046
	2010	0.0071	0.0046
	2011	0.0071	0.0046
	2012	0.0071	0.0046
	2013	0.0071	0.0046
	2014	0.0071	0.0046
	2015	0.0068	0.0042
	2016	0.0065	0.0038
	2017	0.0054	0.0018
	2018	0.0052	0.0016
	2019	0.0051	0.0015
	2020	0.0050	0.0014
	2021	0.0051	0.0014
Gasoline Light-Duty Trucks (Vans, Pickup Trucks, SUVs)	1973-1974	0.1908	0.0218
	1975	0.1634	0.0513
	1976	0.1594	0.0555
	1977-1978	0.1614	0.0534
	1979-1980	0.1594	0.0555
	1981	0.1479	0.0660
	1982	0.1442	0.0681
	1983	0.1368	0.0722
	1984	0.1294	0.0764
	1985	0.1220	0.0806
	1986	0.1146	0.0848
	1987-1993	0.0813	0.1035
	1994	0.0646	0.0982
	1995	0.0517	0.0908
	1996	0.0452	0.0871
	1997	0.0452	0.0871
	1998	0.0412	0.0787
	1999	0.0333	0.0618
	2000	0.0340	0.0631
	2001	0.0221	0.0379
	2002	0.0242	0.0424
	2003	0.0221	0.0373
	2004	0.0115	0.0088
	2005	0.0105	0.0064
	2006	0.0108	0.0080
	2007	0.0103	0.0061
	2008	0.0095	0.0036
	2009	0.0095	0.0036
	2010	0.0095	0.0035
	2011	0.0096	0.0034
	2012	0.0096	0.0033
	2013	0.0095	0.0035
	2014	0.0095	0.0033
	2015	0.0094	0.0031
	2016	0.0091	0.0029
	2017	0.0084	0.0018
	2018	0.0081	0.0015
	2019	0.0080	0.0013
	2020	0.0079	0.0012
	2021	0.0079	0.0012
Gasoline Heavy-Duty Vehicles	≤1980	0.4604	0.0497
	1981-1984	0.4492	0.0538
	1985-1986	0.4090	0.0515
	1987	0.3675	0.0849
	1988-1989	0.3492	0.0933
	1990-1995	0.3246	0.1142
	1996	0.1278	0.1680
	1997	0.0924	0.1726
	1998	0.0655	0.1750
	1999	0.0648	0.1724
	2000	0.0630	0.1660
	2001	0.0577	0.1468
	2002	0.0634	0.1673
	2003	0.0602	0.1553
	2004	0.0298	0.0164
	2005	0.0297	0.0083
	2006	0.0299	0.0241
	2007	0.0322	0.0015
	2008	0.0340	0.0015
	2009	0.0339	0.0015
	2010	0.0320	0.0015
	2011	0.0304	0.0015
	2012	0.0313	0.0015
	2013	0.0313	0.0015
	2014	0.0315	0.0015
	2015	0.0332	0.0021
	2016	0.0321	0.0061
	2017	0.0329	0.0084
	2018	0.0326	0.0082
	2019	0.0330	0.0091
	2020	0.0332	0.0100
	2021	0.0332	0.0100
Gasoline Motorcycles	1960-1995	0.0070	0.0083
	1996-2005	0	0
	2006-2020	0.0070	0.0083

Emission Factor Calculation
Light Duty Trucks:
0.01021 tCO2e/Gallon
Diesel Busses
0.01021 tCO2e/Gallon

Source: EPA (2023) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021 (Annexes). All values are calculated from Tables A-81 through A-85.

Notes:
The factors represented in the table above represent combustion emissions only (tank-to-wheel) and do not represent upstream emissions or well-to-wheel emissions.

Table 4 Mobile Combustion CH_4 and N_2O for On-Road Diesel and Alternative Fuel Vehicles

Vehicle Type	Fuel Type	Model Year	CH_4 Factor (g CH_4 / vehicle-mile)	N_2O Factor (g N_2O / vehicle-mile)
Passenger Cars	Diesel	1960-1982	0.0006	0.0012
		1983-2006	0.0005	0.0010
		2007-2021	0.0302	0.0192
Light-Duty Trucks	Diesel	1960-1982	0.0011	0.0017
		1983-2006	0.0009	0.0014
		2007-2021	0.0290	0.0214
Medium- and Heavy-Duty Vehicles	Diesel	1960-2006	0.0051	0.0048
		2007-2021	0.0095	0.0431

Light-Duty Cars	Methanol		0.0130	0.0040
	Ethanol		0.0130	0.0040
	CNG		0.1330	0.0040
	LPG		0.0130	0.0040
	Biodiesel		0.0360	0.0010
Light-Duty Trucks	Ethanol		0.0140	0.0050
	CNG		0.1440	0.0050
	LPG		0.0140	0.0050
	LNG		0.1440	0.0050
	Biodiesel		0.1270	0.0010
Medium-Duty Trucks	CNG		1.8070	0.0340
	LPG		0.1810	0.0340
	LNG		1.8070	0.0340
	Biodiesel		0.0400	0.0050
Heavy-Duty Trucks	Methanol		0.0730	0.0270
	Ethanol		0.0730	0.0270
	CNG		0.9210	0.0170
	LPG		0.0920	0.0170
	LNG		0.9210	0.0170
	Biodiesel		0.0140	0.0020
Buses	Methanol		0.1930	0.0290
	Ethanol		0.1930	0.0290
	CNG		2.7530	0.0170
	LPG		0.2750	0.0170
	LNG		2.7530	0.0170
	Biodiesel		0.0160	0.0030

Source: EPA (2023) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021 (Annexes). All values are calculated from Tables A-84 through A-85.
https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks
Notes:
The factors represented in the table above represent combustion emissions only (tank-to-wheel) and do not represent upstream emissions or well-to-wheel emissions.

Table 5 Mobile Combustion CH_4 and N_2O for Non-Road Vehicles

Vehicle Type	Fuel Type	CH_4 Factor (g CH_4 / gallon)	N_2O Factor (g N_2O / gallon)
Ships and Boats	Residual Fuel Oil	1.10	0.31
	Gasoline (2 stroke)	4.64	0.08
	Gasoline (4 stroke)	2.26	0.01
	Diesel	6.41	0.17
Locomotives	Diesel	0.80	0.26
Aircraft	Jet Fuel	0	0.30
	Aviation Gasoline	7.06	0.11
Agricultural Equipment[A]	Gasoline (2 stroke)	6.92	0.47
	Gasoline (4 stroke)	1.94	1.21
	Gasoline Off-Road Trucks	1.94	1.20
	Diesel Equipment	1.27	1.07
	Diesel Off-Road Trucks	0.91	0.56
	LPG	0.33	0.95
Construction/Mining Equipment[B]	Gasoline (2 stroke)	7.98	0.12
	Gasoline (4 stroke)	2.85	1.47
	Gasoline Off-Road Trucks	2.85	1.47
	Diesel Equipment	1.01	0.94
	Diesel Off-Road Trucks	0.91	0.56
	LPG	0.59	0.50
Lawn and Garden Equipment	Gasoline (2 stroke)	7.29	0.31
	Gasoline (4 stroke)	3.00	1.49
	Diesel	0.66	0.49
	LPG	0.41	0.63
Airport Equipment	Gasoline	1.02	1.07
	Diesel	1.89	1.16
	LPG	0.35	0.89
Industrial/Commercial Equipment	Gasoline (2 stroke)	7.13	0.50
	Gasoline (4 stroke)	2.74	1.54
	Diesel	0.42	0.60
	LPG	0.44	0.64
Logging Equipment	Gasoline (2 stroke)	9.68	0
	Gasoline (4 stroke)	3.24	2.06
	Diesel	0.49	1.27
Railroad Equipment	Gasoline	3.24	1.81
	Diesel	0.40	0.95
	LPG	2.00	0.01
Recreational Equipment	Gasoline (2 stroke)	9.80	0.11
	Gasoline (4 stroke)	2.72	1.48
	Diesel	0.73	0.66
	LPG	0.43	0.61

0.0102100 tCO2e/Gallon

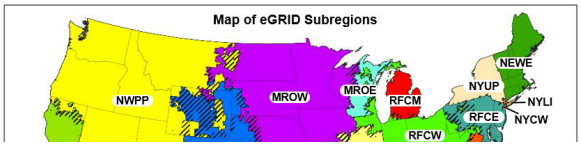
Source: EPA (2023) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021 (Annexes). All values are calculated from Tables A-88 and A-92.
https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks
Notes:
The factors represented in the table above represent combustion emissions only (tank-to-wheel) and do not represent upstream emissions or well-to-wheel emissions.
[A] Includes equipment, such as tractors and combines, as well as fuel consumption from trucks that are used off-road in agriculture.
[B] Includes equipment, such as cranes, dumpers, and excavators, as well as fuel consumption from trucks that are used off-road in construction.

Convert lbs to metric tonnes *0.00045359*

Table 6 Electricity

eGRID Subregion Acronym	eGRID Subregion Name	Total Output Emission Factors			Non-Baseload Emission Factors			tCO2e	tCO2e
		CO_2 Factor (lb CO_2 / MWh)	CH_4 Factor (lb CH_4 / MWh)	N_2O Factor (lb N_2O / MWh)	CO_2 Factor (lb CO_2 / MWh)	CH_4 Factor (lb CH_4 / MWh)	N_2O Factor (lb N_2O / MWh)	(lb / MWh)	t / MWh)
AKGD	ASCC Alaska Grid	1,052.1	0.088	0.012	1,224.5	0.123	0.017	1,052.11	0.48
AKMS	ASCC Miscellaneous	495.8	0.023	0.004	1,587.9	0.069	0.012	495.77	0.22
AZNM	WECC Southwest	776.0	0.051	0.007	1,205.2	0.065	0.009	776.04	0.35
CAMX	WECC California	497.4	0.030	0.004	1,055.0	0.049	0.006	497.44	0.23
ERCT	ERCOT All	771.1	0.049	0.007	1,194.9	0.067	0.009	771.08	0.35
FRCC	FRCC All	813.8	0.048	0.006	1,044.4	0.056	0.007	813.85	0.37
HIMS	HICC Miscellaneous	1,155.5	0.124	0.019	1,619.2	0.157	0.025	1,155.49	0.52
HIOA	HICC Oahu	1,575.4	0.163	0.025	1,810.3	0.177	0.028	1,575.41	0.71
MROE	MRO East	1,479.6	0.133	0.019	1,672.9	0.147	0.021	1,479.62	0.67
MROW	MRO West	936.5	0.102	0.015	1,794.7	0.183	0.026	936.49	0.42
NEWE	NPCC New England	536.4	0.063	0.008	923.3	0.073	0.010	536.43	0.24
NWPP	WECC Northwest	602.1	0.056	0.008	1,515.7	0.134	0.019	602.09	0.27
NYCW	NPCC NYC/Westchester	885.2	0.023	0.003	971.8	0.021	0.002	885.23	0.40
NYLI	NPCC Long Island	1,200.7	0.135	0.018	1,316.7	0.039	0.005	1,200.71	0.54
NYUP	NPCC Upstate NY	274.6	0.015	0.002	920.1	0.043	0.005	274.56	0.12
PRMS	Puerto Rico Miscellaneous	1,593.5	0.087	0.014	1,670.9	0.074	0.013	1,593.48	0.72
RFCE	RFC East	657.4	0.045	0.006	1,278.7	0.097	0.013	657.39	0.30
RFCM	RFC Michigan	1,216.4	0.116	0.016	1,597.3	0.149	0.021	1,216.40	0.55
RFCW	RFC West	1,000.1	0.087	0.012	1,843.6	0.178	0.026	1,000.05	0.45
RMPA	WECC Rockies	1,124.9	0.101	0.014	1,676.4	0.129	0.018	1,124.89	0.51
SPNO	SPP North	952.6	0.100	0.014	1,943.0	0.198	0.029	952.58	0.43
SPSO	SPP South	970.4	0.072	0.010	1,528.2	0.105	0.015	970.40	0.44
SRMV	SERC Mississippi Valley	801.0	0.040	0.006	1,220.7	0.073	0.010	801.02	0.36
SRMW	SERC Midwest	1,369.9	0.151	0.022	1,808.6	0.186	0.027	1,369.89	0.62
SRSO	SERC South	893.3	0.064	0.009	1,354.8	0.092	0.013	893.29	0.41
SRTV	SERC Tennessee Valley	933.1	0.082	0.012	1,671.0	0.152	0.022	933.07	0.42
SRVC	SERC Virginia/Carolina	623.0	0.047	0.007	1,308.8	0.099	0.014	622.99	0.28
US Average	US Average	823.1	0.066	0.009	1,405.3	0.107	0.015	823.15	0.37

Source: EPA eGRID2022, January 2024 (Summary Tables - Table 1. Subregion Output Emission Rates)
https://www.epa.gov/system/files/documents/2024-01/egrid2022_summary_tables.xlsx
Notes:
Total output emission factors can be used as default factors for estimating GHG emissions from electricity use when developing a carbon footprint or emissions inventory. Annual non-baseload output emission factors should not be used when developing a carbon footprint or emissions inventory, but can be used to estimate GHG emissions reductions on the grid from changes in electricity use.
For technical information, reference the EPA's eGRID Technical Guide
https://www.epa.gov/system/files/documents/2024-01/egrid2022_technical_guide.pdf
The factors represented in the table above represent combustion emissions only (tank-to-wheel) and do not represent upstream emissions or well-to-wheel emissions.



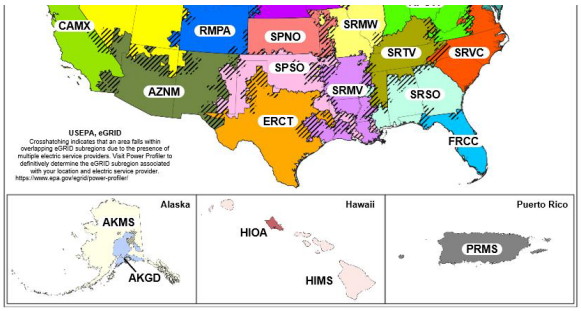


Table 7 Steam and Heat

	CO_2 Factor (kg CO_2 / mmBtu)	CH_4 Factor (g CH_4 / mmBtu)	N_2O Factor (g N_2O / mmBtu)
Steam and Heat	66.33	1.250	0.125

Notes:
Emission factors are per mmBtu of steam or heat purchased. These factors assume natural gas fuel is used to generate steam or heat at 80 percent thermal efficiency.
The factors represented in the table above represent combustion emissions only (tank-to-wheel) and do not represent upstream emissions or well-to-wheel emissions.

Scope 3 Emission Factors

Scope 3 emission factors provided below are aligned with the Greenhouse Gas Protocol Technical Guidance for Calculating Scope 3 Emissions, version 1.0 (Scope 3 Calculation Guidance). Where applicable, the specific calculation method is referenced. Refer to the Scope 3 Calculation Guidance for more information (http://www.ghgprotocol.org/scope-3-technical-calculation-guidance)

Table 8 Scope 3 Category 4: Upstream Transportation and Distribution and Category 9: Downstream Transportation and Distribution

These factors are intended for use in the distance-based method defined in the Scope 3 Calculation Guidance. If fuel data are available, then the fuel-based method should be used, with factors from Tables 2 through 5.

Vehicle Type	CO_2 Factor (kg CO_2 / unit)	CH_4 Factor (g CH_4 / unit)	N_2O Factor (g N_2O / unit)	Units
Medium- and Heavy-Duty Truck	1.247	0.011	0.035	vehicle-mile
Passenger Car [A]	0.175	0.005	0.003	vehicle-mile
Light-Duty Truck [B]	0.955	0.026	0.023	vehicle-mile
Medium- and Heavy-Duty Truck [C]	0.168	0.0015	0.0047	ton-mile
Rail	0.022	0.0017	0.0005	ton-mile
Waterborne Craft	0.082	0.0326	0.0021	ton-mile
Aircraft	0.905	0	0.0279	ton-mile

Source:
CO_2, CH_4, and N_2O emissions data for road vehicles are from Table 2-13 of the EPA (April 2023) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021 data.
Vehicle-miles and passenger-miles data for road vehicles are from Table VM-1 of the Federal Highway Administration Highway Statistics (January 2024): 2021 data.
CO_2e emissions data for non-road vehicles are based on Table A-107 of the EPA (April 2023) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021 data, which are distributed into CO_2, CH_4, and N_2O emissions based on fuel/vehicle emission factors.
Freight ton-mile data are from Table 1-50 of the Bureau of Transportation Statistics, National Transportation Statistics (June 2022): 2020 data.

Notes:
Vehicle-mile factors are appropriate to use when the entire vehicle is dedicated to transporting the reporting company's product. Ton-mile factors are appropriate when the vehicle is shared with products from other companies.
The factors represented in the table above represent combustion emissions only (tank-to-wheel) and do not represent upstream emissions or well-to-wheel emissions.
Changes from prior year values partially due to a methodology change in the allocation of emissions to vehicle type.
[A] Passenger car: includes passenger cars, minivans, SUVs, and small pickup trucks (vehicles with wheelbase less than 121 inches).
[B] Light-duty truck: includes full-size pickup trucks, full-size vans, and extended-length SUVs (vehicles with wheelbase greater than 121 inches).
[C] Medium- and Heavy-Duty Truck: includes Combination Trucks and single frame trucks that have 2-Axles and at least 6 tires or a gross vehicle weight rating exceeding 10,000 lbs.

Table 9 Scope 3 Category 5: Waste Generated in Operations and Category 12: End-of-Life Treatment of Sold Products

These factors are intended for use in the waste-type-specific method or the average-data method defined in the Scope 3 Calculation Guidance for category 5 and category 12. Choose the appropriate material and disposal method from the table below. For the average-data method, use one of the mixed material types, such as mixed MSW.

	Metric Tons CO_2e / Short Ton Material					
Material	Recycled [A]	Landfilled [B]	Combusted [C]	Composted [D]	Anaerobically Digested (Dry Digestate with Curing)	Anaerobically Digested (Wet Digestate with Curing)
Aluminum Cans	0.06	0.02	0.01	NA	NA	NA
Aluminum Ingot	0.04	0.02	0.01	NA	NA	NA
Steel Cans	0.32	0.02	0.01	NA	NA	NA
Copper Wire	0.18	0.02	0.01	NA	NA	NA
Glass	0.05	0.02	0.01	NA	NA	NA
HDPE	0.21	0.02	2.80	NA	NA	NA
LDPE	NA	0.02	2.80	NA	NA	NA
PET	0.23	0.02	2.05	NA	NA	NA
LLDPE	NA	0.02	2.80	NA	NA	NA
PP	0.20	0.02	2.80	NA	NA	NA
PS	NA	0.02	3.02	NA	NA	NA
PVC	NA	0.02	1.26	NA	NA	NA
PLA	NA	0.02	0.01	0.13	NA	NA
Corrugated Containers	0.11	1.00	0.05	NA	NA	NA
Magazines/Third-class mail	0.02	0.46	0.05	NA	NA	NA
Newspaper	0.02	0.39	0.05	NA	NA	NA
Office Paper	0.02	1.41	0.05	NA	NA	NA
Phonebooks	0.04	0.39	0.05	NA	NA	NA
Textbooks	0.04	1.41	0.05	NA	NA	NA
Dimensional Lumber	NA	0.17	0.05	NA	NA	NA
Medium-density Fiberboard	NA	0.07	0.05	NA	NA	NA
Food Waste (non-meat)	NA	0.67	0.05	0.11	0.14	0.11
Food Waste (meat only)	NA	0.69	0.05	0.11	0.14	0.11
Beef	NA	0.64	0.05	0.11	0.14	0.11
Poultry	NA	0.73	0.05	0.11	0.14	0.11
Grains	NA	2.06	0.05	0.11	0.14	0.11
Bread	NA	1.49	0.05	0.11	0.14	0.11
Fruits and Vegetables	NA	0.28	0.05	0.11	0.14	0.11
Dairy Products	NA	0.72	0.05	0.11	0.14	0.11
Yard Trimmings	NA	0.36	0.05	0.14	0.11	NA
Grass	NA	0.28	0.05	0.14	0.09	NA
Leaves	NA	0.28	0.05	0.14	0.12	NA
Branches	NA	0.58	0.05	0.14	0.15	NA
Mixed Paper (general)	0.07	0.89	0.05	NA	NA	NA
Mixed Paper (primarily residential)	0.07	0.86	0.05	NA	NA	NA
Mixed Paper (primarily from offices)	0.03	0.84	0.05	NA	NA	NA
Mixed Metals	0.23	0.02	0.01	NA	NA	NA
Mixed Plastics	0.22	0.02	2.34	NA	NA	NA
Mixed Recyclables	0.09	0.75	0.11	NA	NA	NA
Food Waste	NA	0.68	0.05	0.11	NA	NA
Mixed Organics	NA	0.54	0.05	0.13	NA	NA
Mixed MSW	NA	0.58	0.43	NA	NA	NA
Carpet	NA	0.02	1.68	NA	NA	NA
Desktop CPUs	0.01	0.02	0.40	NA	NA	NA
Portable Electronic Devices	0.02	0.02	0.89	NA	NA	NA
Flat-panel Displays	0.02	0.02	0.74	NA	NA	NA
CRT Displays	NA	0.02	0.64	NA	NA	NA
Electronic Peripherals	0.05	0.02	2.23	NA	NA	NA
Hard-copy Devices	0.01	0.02	1.92	NA	NA	NA
Mixed Electronics	0.02	0.02	0.96	NA	NA	NA
Clay Bricks	NA	0.02	NA	NA	NA	NA
Concrete	0.01	0.02	NA	NA	NA	NA
Fly Ash	0.01	0.02	NA	NA	NA	NA
Tires	0.10	0.02	2.21	NA	NA	NA
Asphalt Concrete	0.004	0.02	NA	NA	NA	NA
Asphalt Shingles	0.03	0.02	0.70	NA	NA	NA
Drywall	NA	0.02	NA	NA	NA	NA
Fiberglass Insulation	0.05	0.02	NA	NA	NA	NA
Structural Steel	0.04	0.02	NA	NA	NA	NA
Vinyl Flooring	NA	0.02	0.29	NA	NA	NA
Wood Flooring	NA	0.18	0.08	NA	NA	NA

Source:

U.S. Environmental Protection Agency, Office of Resource Conservation and Recovery (December 2023) Documentation for Greenhouse Gas Emission and Energy Factors used in the Waste Reduction Model (WARM). Factors from tables provided in the Management Practices Chapters and Background Chapters. WARM Version 16, December 2023 release. Additional data provided by EPA, WARM-16 Background Data.

Notes:
These factors do not include any avoided emissions impact from any of the disposal methods. All the factors presented here include transportation emissions, which are optional in the Scope 3 Calculation Guidance, with an assumed average distance traveled to the processing facility.
AR4 GWP values are used to convert all waste emission factors into CO_2e.
Short ton = 2000 lbs.
[A] Recycling emissions include transport to recycling facility and sorting of recycled materials at material recovery facility. This is consistent with the GHG Protocol Scope 3 guidance, and includes the voluntary transportation emissions, with an assumed average distance traveled to the processing facility.
[B] Landfilling emissions include transport to landfill, equipment use at landfill and landfill CH_4 emissions from anaerobic decomposition of biogenic carbon compounds. Landfill CH_4 is based on typical landfill gas collection practices, average landfill moisture conditions, and U.S.-average non-baseload electricity grid mix.
[C] Combustion emissions include transport to waste-to-energy facility and combustion-related non-bigenic CO_2 and N_2O. This is consistent with the GHG Protocol Scope 3 guidance, and includes the voluntary transportation emissions, with an assumed average distance traveled to the processing facility.
[D] Composting emissions include transport to compost facility, equipment use at compost facility and CH_4 and N_2O emissions during composting. This is consistent with the GHG Protocol Scope 3 guidance, and includes the voluntary transportation emissions, with an assumed average distance traveled to the processing facility.

Table 10 Scope 3 Category 6: Business Travel and Category 7: Employee Commuting

These factors are intended for use in the distance-based method defined in the Scope 3 Calculation Guidance. If fuel data are available, then the fuel-based method should be used, with factors from Tables 2 through 5.

Vehicle Type	CO_2 Factor (kg CO_2 / unit)	CH_4 Factor (g CH_4 / unit)	N_2O Factor (g N_2O / unit)	Units
Passenger Car [A]	0.175	0.005	0.003	vehicle-mile
Light-Duty Truck [B]	0.955	0.026	0.023	vehicle-mile
Motorcycle	0.377	0	0.019	vehicle-mile
Intercity Rail - Northeast Corridor [C]	0.058	0.0055	0.0007	passenger-mile
Intercity Rail - Other Routes [C]	0.150	0.0117	0.0038	passenger-mile
Intercity Rail - National Average [C]	0.113	0.0092	0.0026	passenger-mile
Commuter Rail [D]	0.133	0.0105	0.0026	passenger-mile
Transit Rail (i.e. Subway, Tram) [E]	0.093	0.0075	0.0010	passenger-mile
Bus	0.071	0	0.0021	passenger-mile
Air Travel - Short Haul (< 300 miles)	0.207	0.0064	0.0066	passenger-mile
Air Travel - Medium Haul (>= 300 miles, < 2300 miles)	0.129	0.0006	0.0041	passenger-mile
Air Travel - Long Haul (>= 2300 miles)	0.163	0.0006	0.0052	passenger-mile

Source:
CO_2, CH_4, and N_2O emissions data for highway vehicles are from Table 2-13 of the EPA (April 2023) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021 data.
Vehicle-miles and passenger-miles data for highway vehicles are from Table VM-1 of the Federal Highway Administration Highway Statistics (January 2024): 2021 data.
Fuel consumption data and passenger-miles data for rail are from Tables A.14 - A.16, 10-10, and 7.3 - 7.4 of the Transportation Energy Data Book: Edition 40 (June 2022): 2019 data. Fuel consumption was converted to emissions by using fuel and electricity emission factors presented in the tables above.
Intercity Rail factors from communication with Amtrak, March 2020. These are based on 2019 values.
Air Travel factors from 2022 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting. Version 2.0 June 2022. Defra air travel emission factors held constant from 2022 release (2018 activity data) to more accurately reflect the current state of business travel as the 2023 Defra release reflects significantly reduced load factors during COVID-19.

Notes:
The factors represented in the table above represent combustion emissions only (tank-to-wheel) and do not represent upstream emissions or well-to-wheel emissions.
Changes from prior year values partially due to a methodology change in the allocation of emissions to vehicle type.
[A] Passenger car: includes passenger cars, minivans, SUVs, and small pickup trucks (vehicles with wheelbase less than 121 inches).
[B] Light-duty truck: includes full-size pickup trucks, full-size vans, and extended-length SUVs (vehicles with wheelbase greater than 121 inches).
[C] Intercity rail: Amtrak long-distance rail between major cities. Northeast Corridor extends from Boston to Washington D.C. Other Routes are all routes outside the Northeast Corridor.
[D] Commuter rail: rail service between a central city and adjacent suburbs (also called regional rail or suburban rail).
[E] Transit rail: rail typically within an urban center, such as subways, elevated railways, metropolitan railways (metro), streetcars, trolley cars, and tramways.

Global Warming Potential

Table 11 Global Warming Potential (GWP)

Industrial Designation or Common Name	Chemical Formula	100-Year GWP
Carbon dioxide	CO_2	1
Methane	CH_4	28
Nitrous oxide	N_2O	265
HFC-23	CHF_3	12,400
HFC-32	CH_2F_2	677
HFC-41	CH_3F	116
HFC-125	CHF_2CF_3	3,170
HFC-134	CHF_2CHF_2	1,120
HFC-134a	CH_2FCF_3	1,300
HFC-143	CH_2FCHF_2	328
HFC-143a	CH_3CF_3	4,800
HFC-152	CH_2FCH_2F	16
HFC-152a	CH_3CHF_2	138
HFC-161	CH_3CH_2F	4
HFC-227ea	CF_3CHFCF_3	3,350
HFC-236cb	$CH_2FCF_2CF_3$	1,210
HFC-236ea	CHF_2CHFCF_3	1,330
HFC-236fa	$CF_3CH_2CF_3$	8,060
HFC-245ca	$CH_2FCF_2CHF_2$	716
HFC-245fa	$CHF_2CH_2CF_3$	858
HFC-365mfc	$CH_3CF_2CH_2CF_3$	804
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	1,650
Sulfur hexafluoride	SF_6	23,500
Nitrogen trifluoride	NF_3	16,100
PFC-14	CF_4	6,630
PFC-116	C_2F_6	11,100
PFC-218	C_3F_8	8,900
PFC-318	c-C_4F_8	9,540
PFC-31-10	C_4F_{10}	9,200
PFC-41-12	C_5F_{12}	8,550
PFC-51-14	C_6F_{14}	7,910
PFC-91-18	$C_{10}F_{18}$	7,190

Source:
100-year GWP values from IPCC Fifth Assessment Report (AR5), 2013. Chapter 8, Table 8.A.1, Lifetimes, Radiative Efficiencies and Metric Values.
IPCC AR5 was published in 2013 and is among the most current and comprehensive peer-reviewed assessments of climate change. AR5 provides revised GWP values of several GHGs relative to the values provided in previous assessment reports, following advances in scientific knowledge on the radiative efficiencies and atmospheric lifetimes of these GHGs.

Table 12 Global Warming Potential (GWP) for Blended Refrigerants

ASHRAE #	100-year GWP	Blend Composition
R-401A	18	53% HCFC-22 , 34% HCFC-124 , 13% HFC-152a
R-401B	15	61% HCFC-22 , 28% HCFC-124 , 11% HFC-152a
R-401C	21	33% HCFC-22 , 52% HCFC-124 , 15% HFC-152a
R-402A	1,902	38% HCFC-22 , 60% HFC-125 , 2% propane
R-402B	1,205	60% HCFC-22 , 38% HFC-125 , 2% propane
R-403B	3,471	56% HCFC-22 , 39% PFC-218 , 5% propane
R-404A	3,943	44% HFC-125 , 4% HFC-134a , 52% HFC-143a
R-406A	0	55% HCFC-22 , 41% HCFC-142b , 4% isobutane
R-407A	1,923	20% HFC-32 , 40% HFC-125 , 40% HFC-134a
R-407B	2,547	10% HFC-32 , 70% HFC-125 , 20% HFC-134a
R-407C	1,624	23% HFC-32 , 25% HFC-125 , 52% HFC-134a
R-407D	1,487	15% HFC-32 , 15% HFC-125 , 70% HFC-134a
R-408A	2,430	47% HCFC-22 , 7% HFC-125 , 46% HFC-143a
R-409A	0	60% HCFC-22 , 25% HCFC-124 , 15% HCFC-142b
R-410A	1,924	50% HFC-32 , 50% HFC-125
R-410B	2,048	45% HFC-32 , 55% HFC-125
R-411A	15	87.5% HCFC-22 , 11% HFC-152a , 1.5% propylene
R-411B	4	94% HCFC-22 , 3% HFC-152a , 3% propylene
R-414A	0	51% HCFC-22 , 28.5% HCFC-124 , 16.5% HCFC-142b , 4% isobutane
R-414B	0	50% HCFC-22 , 39% HCFC-124 , 9.5% HCFC-142b , 1.5% isobutane
R-417A	2,127	46.6% HFC-125 , 50% HFC-134a , 3.4% butane
R-422A	2,847	85.1% HFC-125 , 11.5% HFC-134a , 3.4% isobutane
R-422D	2,473	65.1% HFC-125 , 31.5% HFC-134a , 3.4% isobutane
R-424A	3,104	50.5% HFC-125 , 47% HFC-134a , 1% butane , 0.9% isobutane , 0.6% isopentane
R-426A	1,371	5.1% HFC-125 , 93% HFC-134a , 1.3% butane , 0.6% isobutane
R-428A	3,417	77.5% HFC-125 , 20% HFC-143a , 1.9% isobutane , 0.6% propane
R-434A	3,075	63.2% HFC-125 , 16% HFC-134a , 18% HFC-143a , 2.8% isobutane
R-507A	3,985	50% HFC-125 , 50% HFC-143a
R-508A	11,607	39% HFC-23 , 61% PFC-116
R-508B	11,698	46% HFC-23 , 54% PFC-116

Source:
100-year GWP values from IPCC Fifth Assessment Report (AR5), 2013. Chapter 8, Table 8.A.1, Lifetimes, Radiative Efficiencies and Metric Values.
GWP values of blended refrigerants are based only on their HFC and PFC constituents, which are based on data from https://www.epa.gov/snap/compositions-refrigerant-blends.