Eastern Research Group, Inc.

2022 National Emissions Inventory Locomotive Methodology

Prepared for:

U.S. Environmental Protection Agency

Air and Radiation

109 T.W. Alexander Drive

Research Triangle Park, NC 27711

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June 7, 2024

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2022 National Emissions Inventory: Rail Methodology

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Acronym List

Acronym	Definition
AAR	Association of American Railroads
ASLRRA	American Short Line and Railroad Association
BNSF	Burlington Northern Santa Fe
CH_4	Methane
CN	Canadian National Railway
CO_2	Carbon Dioxide
CO	Carbon Monoxide
CPRS	Canadian Pacific Railway
CSXT	CSX Transportation
EF	Emission Factors
EIAG	Emission Inventory and Analysis Group
EIS	Emissions Inventory System
EPA	Environmental Protection Agency
ERG	Easton Research Group, Inc.
FTA	Federal Transit Administration
GIS	Geographic information system
HAP	Hazardous Air Pollutants
HC	Hydrocarbon
KCS	Kansas City Southern Railroad
MBTA	Massachusetts Bay Transportation Authority
MGT	Million gross ton
NEI	National Emissions Inventory
NH_3	Ammonia
N_2O	Nitrous Oxide
NO_X	Nitrogen Oxides
NS	Norfolk Southern
NTAD	National Transportation Atlas Database
NTD	National Transit Database
OAQPS	Office of Air Quality Planning and Standards
PM_{10}	Particulate matter less than 10 micrometers
$PM_{2.5}$	Particulate matter less than 2.5 micrometers
SCC	Source Classification Codes
SO_2	Sulfur Dioxide
ULSD	Ultra-low sulfur diesel
UP	Union Pacific
VOC	Volatile Organic Compounds

1. EXECUTIVE SUMMARY

The Emission Inventory and Analysis Group (EIAG) at the United States Environmental Protection Agency's (EPA) Office of Air Quality Planning and Standards (OAQPS) triennially produces the National Emission Inventory (NEI). The NEI compiles comprehensive emissions data for criteria pollutants and hazardous air pollutants (HAPs) for mobile, point, and nonpoint sources, including mobile source; aviation, marine vessels, railroads, onroad vehicles and nonroad engines. EPA uses the data in the NEI as a starting point to prepare National Emissions Modeling Platforms that are used to prepare emissions inputs that support air quality modeling studies. These studies support both regulatory and non-regulatory analyses and often require data to be created that represent years other than NEI years, including future years.

Eastern Research Group (ERG) developed the 2022 locomotive component of the NEI for criteria air pollutants. The 2022 inventory will be used to support modeling activities, help with regulatory initiatives, state implementation programs to address concerns in nonattainment areas and address airport-related emission inquiries.

Emissions from diesel locomotives are an emerging issue in urban and regional air quality planning as other emission sectors reduce their impacts. Rail operations cover large sections of the country. Additionally, extensive freight, commuter, and intercity passenger rail operations in large urban areas may be contributing. Line haul activity and emissions are provided by county, and switch-related locomotive emissions are provided at point yard locations.

This section will include an overview of the results, trends, etc. Table 1 summarizes the national emissions totals for the 2022 inventory by source category. Locomotive emissions in sectors increased from 2020 as the sector rebounds from the impacts of the pandemic. The exception is that rail yard emissions decreased, reflecting the reduction in active engine count and, perhaps, greater reliance on Class II and III rail lines.

Table 1. 2022 US Locomotive Emissions by Sector

2022 Rail Sector	2022 Emissions (tons/year)									
	CH_4	CO	CO_2	N_2O	NH_3	NO_X	PM_{10}	PM_{25}	SO_2	VOC
Class I Line Haul	2,610	86,873	33,119,178	848	272	397,291	10,024	9,724	306	15,972
Class I Yard	153.32	5,331	1,945,203	49.83	15.96	33,773	871	845	18.00	2,193
Class 2/3 Line Haul	148.77	4,332	1,887,550	48.35	15.49	33,264	1,003	973	17.46	1,585
Commuter	106.40	3,541	1,349,974	34.58	11.08	17,975	502	487	12.49	795
Amtrak	44.17	1,450	560,382	14.35	4.93	8,452	285	276	5.12	455

2. BACKGROUND

This document details the approach and data sources used for developing 2022 activity and emissions values for the locomotive sector. The 2022 version was developed by EPA using data provided by national, local, and industrial data providers and are outlined in the sections below. The 2022 inventory includes national emissions data for five distinct components based on source classification codes (SCCs) as outlined in Table 2 below. Note that railway maintenance activities are part of the nonroad sector and are not covered in this document.

Table 2. 2022 SCCs for the Rail Sector

SCC	Sector	Description
2285002006	Railroad Equipment; Diesel	Line Haul Locomotives: Class I Operations
2285002007	Railroad Equipment; Diesel	Line Haul Locomotives: Class II / III Operations
2285002008	Railroad Equipment; Diesel	Line Haul Locomotives: Passenger Trains (Amtrak)
2285002009	Railroad Equipment; Diesel	Line Haul Locomotives: Commuter Lines
2285002010	Railroad Equipment; Diesel	Yard Locomotives (nonpoint)
28500201	Railroad Equipment; Diesel	Yard Locomotives (point)

3. CLASS I LINE HAUL INVENTORY DEVELOPMENT

3.1 Class I Line Haul Data

For the 2020 inventory, the Class I railroads granted EPA permission to use the confidential link-level line haul activity geographic information system (GIS) data layer maintained and updated annually by the Federal Railroad Administration (FRA). At the time of inventory development, 2019 million gross ton (MGT) data was the most recent and complete data available (Figure 1). The postprocessed 2020 inventory of rail links trafficked by each Class I railroads with a record for each link/railroad company combination was used as the basis for the spatial allocation of activity in 2022.

EPA collected 2022 Class I line haul fuel use data from the most recent R-1 submittals from the Surface Transportation Board, summarized in Table 3.[1] Consistent with previous inventory efforts, EPA summed line haul and work train fuel usage. The fuel total was then allocated to rail segments proportionate to the 2020 allocation.

[1] Surface Transportation Board. Available at https://www.stb.gov/reports-data/economic-data/annual-report-financial-data/ Retrieved 09 November 2023.

Figure 1. 2019 Class I Line Haul Activity

Table 3. 2022 R-1 Reported Locomotive Fuel Use for Class I Railroads

Class I Railroad	Line Haul Fuel Use (gal)*
BNSF	1,175,184,806
Canadian National (CN)	107,012,486
Canadian Pacific (CPRS)	64,138,533
CSX Transportation (CSXT)	356,002,171
Kansas City Southern (KCS)	64,185,774
Norfolk Southern (NS)	354,139,306
Union Pacific (UP)	839,457,293

* Includes work train fuel usage

The Association of American Railroads (AAR) provided national Class I locomotive tier fleet mix information that reflects engine turnover in the nation and includes active locomotives but not engines held in storage.[2] While 2022 fleet information was not available, AAR did provide a preliminary 2023 fleet mix that reflected active locomotives and excluded those that were held in storage. A locomotive's Tier level determines its allowable emission rates based on the year when it was built and/or re-manufactured. More accurate emission factors for each pollutant were calculated based on the percentage of the operating Class I line haul locomotives for each USEPA Tier-level category (Table 4).

Table 4. 2023 Class I Line Haul Active Fleet Profile by Tier

Class I Line Haul Tier Level	Locomotive Count	Percent of Fleet
Not Classified	256	1.33%
Tier 0 (1973-2001)	951	4.93%
Tier 0+ (Tier 0 rebuilds)	3,024	15.67%
Tier 1 (2002-2004)	64	0.33%
Tier 1+ (Tier 1 rebuilds)	5,672	29.38%
Tier 2 (2005-2011)	389	2.02%
Tier 2+ (Tier 2 rebuilds)	4,451	23.06%
Tier 3 (2012-2014)	2,455	12.72%
Tier 4 (2015 and later)	1,250	6.48%
Tier 4C (Tier 3 specifications, built after 2014)	782	4.05%
Exempt	9	0.05%

3.2 Calculate Class I Weighted Line Haul Emission Factors

Weighted Emission Factors (EF) per pollutant for each gallon of fuel used (grams/gal) were calculated for the US Class I locomotive fleet based on the percentage of line-haul locomotives certified at each regulated Tier-level (Equation 1; Table 4 and Table 5).

$$EF_i = \sum_{T=1}^{10} (EF_{iT} * f_T) \quad \textbf{Equation (1)}$$

where:

EF_i = Weighted Emission Factor for pollutant *i* for Class I locomotive fleet (g/gal).

EF_{iT} = Emission Factor for pollutant *i* for locomotives in Tier T (g/gal) (Table 5).

f_T = Ratio of the Class I locomotive fleet in Tier T total (Table 4) (unitless).

[2] D. Sprinkle, Association of American Railroads (personal communication, April 2, 2023).

While locomotive diesel engines are certified to meet the emission standards for each Tier, actual emission rates may increase over time due to engine wear and degradation of the emissions control systems.

Emission factors for other pollutants are not Tier-specific because these pollutants are not directly regulated by USEPA's locomotive emission standards. Particulate matter less than 2.5 micrometers ($PM_{2.5}$), volatile organic carbon (VOC), sulfur dioxide (SO_2), and ammonia (NH_3) emission factors were derived from EPA guidance.[3] The 2022 SO_2 emission factor is based on the nationwide adoption of 15 parts per million ultra-low sulfur diesel fuel by the rail industry. All emission factors by Tier and 2023 fleet-weighted values are listed in Table 5.

Table 5. 2022 Line-haul Locomotive Emission Factors by Tier, AAR Fleet Mix (g/gal)

Tie	Tier Name	CH	CO	CO_2	N_2O	NH_3	NO_X	PM_{10}	PM_{25}	SO_2	VOC
0	1973-2001	0.8	26.624	10,150	0.26	0.0833	178.88	6.656	6.456	0.0939	10.51
0+	Tier 0 Rebuild	0.8	26.624	10,150	0.26	0.0833	149.76	4.16	4.035	0.0939	6.570
1	2002-2004	0.8	26.624	10,150	0.26	0.0833	139.36	6.656	6.456	0.0939	10.29
1+	Tier 1 Rebuild	0.8	26.624	10,150	0.26	0.0833	139.36	4.16	4.035	0.0939	6.351
2	2005-2011	0.8	26.624	10,150	0.26	0.0833	102.96	3.744	3.631	0.0939	5.694
2+	Tier 2 Rebuild	0.8	26.624	10,150	0.26	0.0833	102.96	1.664	1.614	0.0939	2.847
3	2012-2014	0.8	26.624	10,150	0.26	0.0833	102.96	1.664	1.614	0.0939	2.847
4	2015 and later	0.8	26.624	10,150	0.26	0.0833	20.8	0.312	0.302	0.0939	0.876
4C	Tier 3 Built after 2014	0.8	26.624	10,150	0.26	0.0833	102.96	1.664	1.614	0.0939	2.847
NC	UNCONTROLLED Pre-1973	0.8	26.624	10,150	0.26	0.0833	270.4	6.656	6.456	0.0939	10.51
2022 CI LH Fleet-Weighted		**0.8**	**26.624**	**10,150**	**0.26**	**0.0833**	**121.76**	**3.072**	**2.980**	**0.0939**	**4.895**

3.3 Calculate Emissions per Link

Emissions (E_{iL}) of individual pollutants (i) per railway segment link (L) were calculated using the process described below (Equation 2):

> Link-level fuel use was multiplied by the weighted Class I line-haul emission factor for pollutant i to determine the emissions value for the link.

$$E_{iL} = \sum_{FIP} \mathrm{F}_L * EF_{iRR} \, / \, 907{,}185 \qquad \textbf{Equation (2)}$$

where:

- E_{iL} = Sum of the link level emissions of pollutant i per FIP (tons/year).
- F_L = Fuel usage per link L (gal/year).
- EF_i = Weighted Emission Factor for pollutant i (g/gal).
- RR = Railroad Company.

[3] EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. Available at: https://nepis.epa.gov.

FIP = County Federal Information Processing Standard.

907,185 = g/ton conversion.

3.4 Aggregate Emissions for Inclusion into the 2022 Inventory

The final link-level emissions for each pollutant were aggregated by state/county FIPS code and then formatted for inclusion in USEPA's EIS.

4. Rail Yard Methodology

The 2020 yard inventory was used as the basis for yard component of the 2022 modeling inventory (Figure 2). The spatial allocation remained the same, and the 2022 R-1 reported yard fuel usage was apportioned to each yard as determined by its fraction of the 2020 total fuel use.

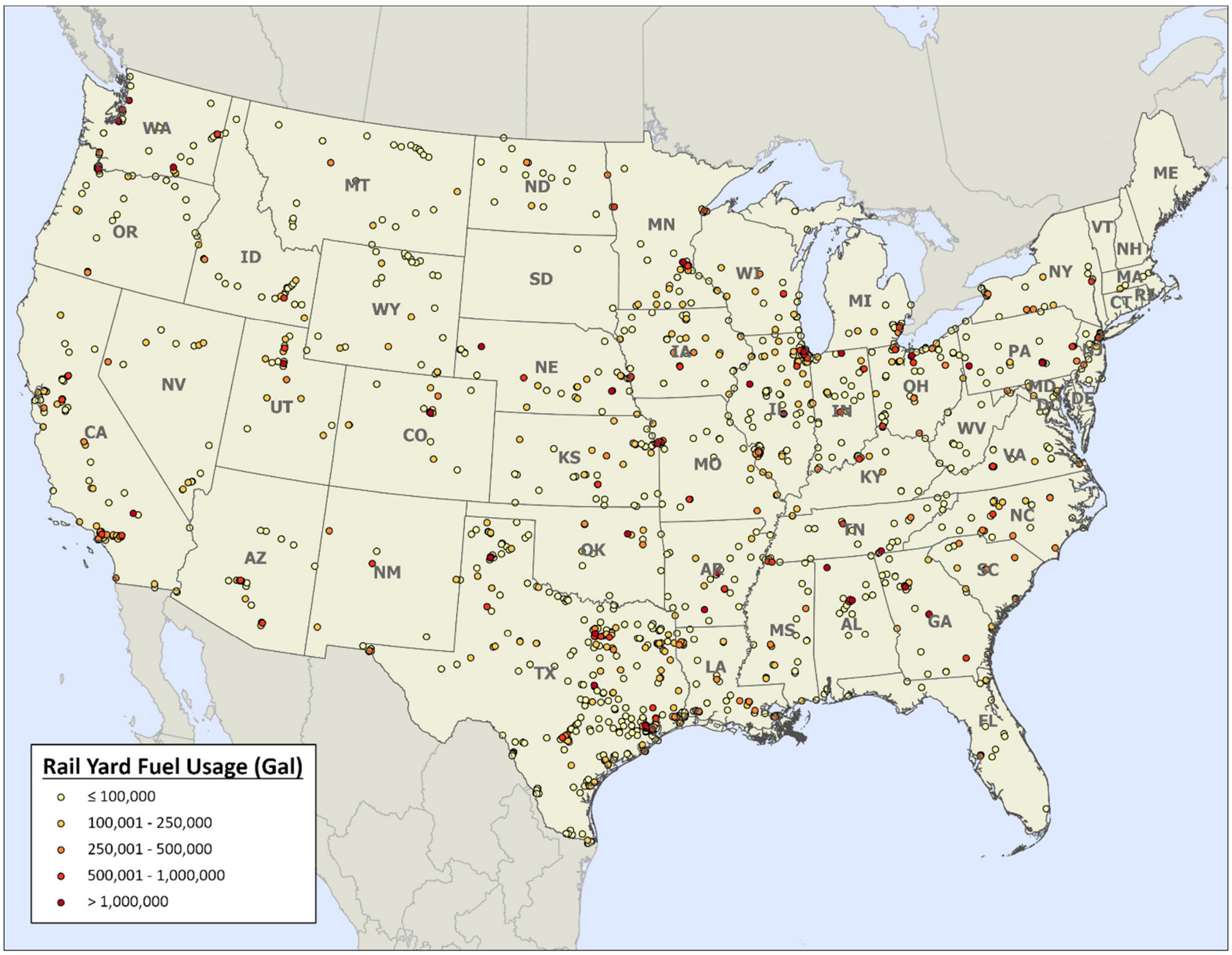

Figure 2. Rail Yard Locations in the United States with 2020 Fuel Usage

AAR provided ERTAC with national tier fleet mix profiles representing the entire Class I yard switching locomotive fleet for 2023. The 2023 fleet mix data reflected the fleet turnover and a shift toward cleaner yard engines, including, for example, the retirement of older switch engines and replacement with cleaner mother-slugs in the yards in Atlanta, Macon, and Rome, GA. The 2023 fleet profile was used to calculate the weighted emissions rates for this 2022 yard inventory (see Table 6).

Table 6. 2023 Class I Yard Switcher Fleet Profile

Tier	Engine Count	Percentage of Fleet
0	485	19.64%
0+	1,565	63.39%
1	85	3.44%
1+	0	0.00%
2	31	1.26%
2+	5	0.20%
3	1	0.04%
4	20	0.81%
Not Classified	273	11.06
Exempt	4	0.16%

5. CLASS II AND III LINE HAUL METHODOLOGY

There are approximately 630 Class II and III railroads operating in the United States.[4] Individual railroads in this sector range from small switching operations to large regional railroads that operate hundreds of miles of track. Data on Class II and III locomotive operations is publicly available from Bureau of Transportation Statistics' National Transportation Atlas Database (NTAD), along with related data including reporting mark, railroad name, route miles owned or operated, and total route miles of links.

5.1 Fleet Profile and Emission Factors

Class II and III railroads are widely dispersed across the country, often utilizing older, higher emitting locomotives than their Class I counterparts. ASLRRA was contacted as it was collecting data regarding the fleet composition; however, data were not complete and available at the time of the 2022 inventory development. As a result, the fleet profile and resulting weighted emission factors from 2020 were used as is for this 2022 effort. AAR provided a national line-haul tier fleet mix profile for 2020 which reflects the trend toward older engines in this sector (Table 7) as compared to Class I rail lines. The national fleet mix data was then used to calculate weighted average in-use emissions factors for the locomotives operated by the Class II and III railroads (Table 8). Note that to be consistent with the 2020 inventory, the unweighted

[4] Association of American Railroads, 2022. Industry Overview, Short Line and Regional. https://www.aar.org/railroad-101/. Accessed 19 April 2022.

emission factors were the same as the Class I line haul due to the conservative use of the EPA's large locomotive conversion factor of 20.8 bhp-hr/gal. Emission factors for $PM_{2.5}$, SO_2, NH_3, VOC, and GHGs were calculated in the same manner as those used for Class I line-haul inventory described above.

Table 7. 2020 Class II/III Line Haul Fleet by Tier Level

Tier	2020 Class II/III Locomotive Count	Percent of Total Fleet
0	1,664	48%
1	31	1%
2	169	5%
3	160	5%
4	64	2%
Not Classified	1,359	39%
Total	**3,447**	**100%**

Table 8. 2020 Class II/III Line Haul Fleet-Weighted Emission Factors (grams/gal)

Pollutant	CH_4	CO	CO_2	N_2O	NH_3	NO_X	PM_{10}	PM_{25}	SO_2	VOC
Class II/III Line Haul	0.8	26.624	10,150	0.26	0.0833	178.9	5.393	5.231	0.0939	8.523

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.

5.2 Emissions Calculations

For the 2022 inventory, ERG researched activity data for the years 2012, 2017, 2020, and 2022 from the U.S. Energy Information Administration's Annual Energy Outlook, shown in Table 9 below.[5] Based on these data, the fuel data used in 2020 was increased across the rail system by 11.6% for the 2022 effort.

Table 9. Rail Freight Values

Rail Freight (quadrillion BTU)			
2012	**2017**	**2020**	**2022**
0.43	0.52	0.44	0.48

[5] USEIA, Annual Energy Outlook 2021. Accessed 3 Apr 2024. Available at https://www.eia.gov/outlooks/aeo/data/browser/#/?id=7-AEO2021&region=0-&cases=highmacro&start=2019&end=2021&f=A&linechart=ref2021-d113020a.5-7-AEO2021&map=&sid=ref2021-d113020a.51-7-AEO2021&sourcekey=0.

Because there was no new data regarding Class II and III engines, the 2020 fleet-weighted emission factors were used to calculate tons of each pollutant emitted annually by county as noted in Equation 3.

$$EC = Fc * EFs/T$$ **Equation (3)**

where:

E_C = County-level Class II & III emissions.

F_c = County-level Class II & III fuel usage (gal).

EFs = weighted emission factors (g/gal).

T = 907,185 g/ton.

6. Commuter Rail Methodology

Commuter rail fuel use data was obtained from the Federal Transit Administration's (FTA) 2022 National Transit Database.[6] MBTA (Massachusetts) and Metra (Illinois) submitted their own fuel use and fleet mix data which was used in place of the NTD data. Table 10 lists the fuel use (gal) for commuter railroads in 2020 and the data source for each.

Table 10. 2022 Fuel Use by Commuter Railroad

Agency	Diesel (Gal)
Altamont Corridor Express	480,481
Central Florida Commuter Rail, dba: SunRail	1,185,090
Central Puget Sound Regional Transit Authority, dba: Sound Transit	861,620
Connecticut Department of Transportation	708,538
Dallas Area Rapid Transit	1,460,507
Fort Worth Transportation Authority, dba: Trinity Metro	615,453
Maryland Transit Administration	4,210,166
Massachusetts Bay Transportation Authority	13,761,972
Metro Transit, dba: Metro Transit	147,088
Metro-North Commuter Railroad Company, dba: MTA Metro-North Railroad	6,882,694
MTA Long Island Railroad	7,310,132
New Jersey Transit Corporation	14,018,352
North County Transit District	855,164
Northeast Illinois Regional Commuter Railroad Corporation, dba: Metra	23,872,392
Northern New England Passenger Rail Authority	870,101
Peninsula Corridor Joint Powers Board, dba: Caltrain	4,118,068
Regional Transportation Authority	190,911
Sonoma-Marin Area Rail Transit District	224,373

[6] FTA, 2022 National Transit Database, 2022 Fuel and Energy. Accessed 27 Oct 2023. Available at https://www.transit.dot.gov/ntd/data-product/2022-fuel-and-energy.

Agency	Diesel (Gal)
South Florida Regional Transportation Authority, dba: TRI-Rail	2,732,169
Southern California Regional Rail Authority, dba: Metrolink	3,255,144
Utah Transit Authority	2,232,114
Virginia Railway Express	1,488,786

Spatial distribution of commuter operations was assumed to be similar between 2020 and 2022. As such, 2020 fuel use by commuter railroad and by county was used as the basis for the 2022 inventory. As noted in Equation 4, company/county-level values were divided by the 2020 total fuel use for each company to identify the percentage of activity represented by each county. Updated 2022 total company-level fuel use was multiplied by this percentage and the fleet-weighted emission factors to calculate tons of each pollutant emitted annually by county.

$$E_{com\text{- }FIP/RR} = F_{2020c\text{-}RR} / F_{2020RR} * F_{2022RR} * EFs / 907{,}185 \qquad \textbf{Equation (4)}$$

where:

$E_{com\text{- }FIP/RR}$	=	County-level (FIP) commuter emissions per commuter line (RR) (tons).
$F_{2020c\text{-}RR}$	=	County-level Commuter 2020 fuel usage per commuter line (RR) (gal).
F_{2020RR}	=	Total commuter 2020 fuel usage for commuter line (RR) (gal).
F_{2022RR}	=	Total 2022 fuel usage for commuter line (RR) (gal).
EFs	=	Weighted commuter emission factors (g/gal).
RR	=	Railroad Company.
T	=	907,185 g/ton.

7. PASSENGER METHODOLOGY (AMTRAK)

For this effort, the 2020 fuel use and emissions were adjusted down based on the fuel use reported in Amtrak's FY22 AMTRAK Sustainability Report as shown in Figure 3. The adjustment was applied uniformly, so the spatial representation of the emissions did not change.

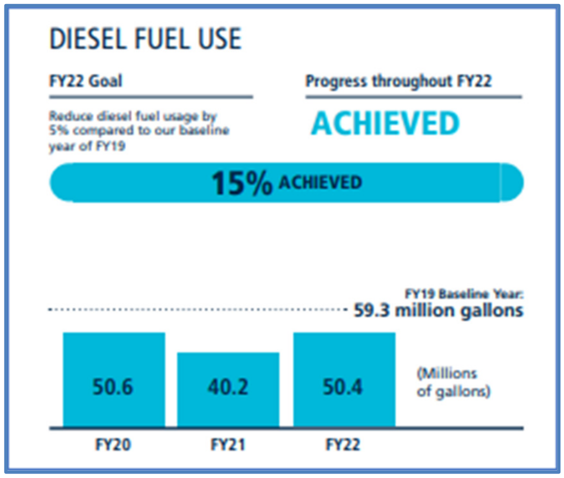

Figure 3. Amtrak Diesel Fuel Use 2020-2022[7]

Upon receipt of state-provided comments, two adjustments were made to Amtrak emissions. First, Delaware verified that all Amtrak passenger service in/through the state utilize electric locomotives only, so fuel usage and emissions for Delaware SCC 2285002008 were removed. Second, Connecticut confirmed that AMTRAK trains operating on electrified lines do not have diesel emissions. The state provided emissions estimates which were used to replace the previously calculated emissions.

8. Emissions Summaries

2022 emissions resulting from the methodology above are presented in Table 11.

Table 11. 2022 US Locomotive Emissions by Sector

2022 Rail Sector	2022 Emissions (tons/year)									
	CH_4	CO	CO_2	N_2O	NH_3	NO_X	PM_{10}	PM_{25}	SO_2	VOC
Class I Line Haul	2,610	86,873	33,119,178	848	272	397,291	10,024	9,724	306	15,972
Class I Yard	153.32	5,331	1,945,203	49.83	15.96	33,773	871	845	18.00	2,193
Class 2/3 Line Haul	148.77	4,332	1,887,550	48.35	15.49	33,264	1,003	973	17.46	1,585
Commuter	106.40	3,541	1,349,974	34.58	11.08	17,975	502	487	12.49	795
Amtrak	44.17	1,450	560,382	14.35	4.93	8,452	285	276	5.12	455

7 Amtrak FY Sustainability Report. Accessed 14 March 2024. https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/environmental1/Amtrak-Sustainability-Report-FY22.pdf.

2020 was a unique year in locomotive activity due to the impacts of the COVID-19 pandemic. In contrast, 2022 shows activity rebounding slowly. Fleet profiles also changed as several older line haul engines were held in storage or redeployed and newer engine purchases/rebuilds were completed and brought out during this challenging time in terms of both demand and efficiency needs (Table 12). While there was an approximately 15% increase in the number of active Class I line haul engines, the emissions increased by less than half that percentage (about 7%). This is due both to increased fuel efficiency and a balanced approach to fleet management and resulting emission factors (Table 13).

Table 12. 2020 and 2023 Class I Line Haul Fleet Profiles by Tier Level

Class I Line Haul Tier Level	2020 Locomotive Count	2023 Locomotive Count	2020 Percent of Fleet	2023 Percent of Fleet
Not Classified	333	256	2%	1%
Tier 0 (1973-2001)	887	951	5%	5%
Tier 0+ (Tier 0 rebuilds)	2,300	3,024	14%	16%
Tier 1 (2002-2004)	119	64	1%	0.3%
Tier 1+ (Tier 1 rebuilds)	4,288	5,672	26%	29%
Tier 2 (2005-2011)	770	389	5%	2%
Tier 2+ (Tier 2 rebuilds)	3,792	4,451	23%	23%
Tier 3 (2012-2014)	2,422	2,455	14%	13%
Tier 4 (2015 and later)	1,181	1,250	7%	6%
Tier 4 Credit (Tier 3 design built 2015 and after)*	695	782	4%	4%
Exempt	0	9	0	0.05%
TOTAL	**16,787**	**19,303**	**100%**	**100%**

Table 13. Class I Line Haul Fleet-Weighted Emission Factors

Pollutant	2020 EF g/gal	2022 EF g/gal
NO_X	120.48	121.76
PM_{10}	3.04	3.07
VOC	4.86	4.9

For Class I yard activities, the trend is somewhat different. The number of active engines and the overall fuel usage decreased from 2020-2022 (Table 14 and Table 15), perhaps reflecting the increasing role of Class II and III rail lines in goods transport.

Table 14. 2020-2022 Yard Engine Fleet Composition Comparison

Tier	2020 Locomotive Count	2022 Locomotive Count	2020 Percent of Fleet	2022 Percent of Fleet
0	673	485	23.75%	19.64%
0+	1,182	1,565	41.71%	63.39%
1	0	85	0.00%	3.44%
1+	26	0	0.92%	0.00%
2	7	31	0.25%	1.26%
2+	0	5	0.00%	0.20%
3	11	1	0.39%	0.04%
4	23	20	0.81%	0.81%
NC	912	273	32.18%	11.06%
Exempt	0	4	0.00%	0.16%
Total	**2,834**	**2,465**	**100%**	**100%**

Table 15. 2020-2022 Switch Engine Counts and Fuel Use

	Yard Engine Count	Fuel Use (gal)
2020	2,890	182,805,846
2022	2,469	173,858,041

The resulting fleet-weighted emission factors in Table 16 are lower than in 2020, reflecting the decrease in utilization of very old (i.e., pre-1973) engines in the yard operations.

Table 16. Class I Yard Fleet-Weighted Emission Factors

Pollutant	2020 EF g/gal	2022 EF g/gal
NO_X	199.84	176.23
PM_{10}	5.24	4.54
VOC	12.98	11.44

Finally, commuter activity and fuel usage (Table 17) show some recovery but still lag behind pre-pandemic levels.

Table 17. Total Commuter Fuel Use (gallons)

Fuel Use	2020	2022
Commuter	104,995,073	91,481,315

This 2022 effort is showing the early stages of adjusting to new and different challenges that resulted from the pandemic's permanent impact on the movement of goods and passengers.

While 2020 was not a typical activity/emissions year, these results provide valuable insight on the strengths, limitations, and flexibility of our rail infrastructure and the companies that define it. Many companies have shown unparalleled ingenuity in adjusting to unprecedented demands on the sector; and other lessons learned over the last few years may be further apparent in future industry developments and reflected in later inventory efforts.

9. Limitations and Future Considerations

Emission inventory development is ever evolving, such that future improvements to the locomotive component of NEI are possible through expanded availability of activity data and processing capabilities. Some potential avenues for increased accuracy include the following:

- Develop activity and emissions at the rail segment level for improved spatial accuracy. This could have particular benefit to modeling efforts to better understand how local air quality is affected by locomotive activities, including impacts within environmental justice communities.
- While fleet profiles of active locomotive engines improve emission factor refinement, current emission estimates assume equal activity by each locomotive regardless of age. More refined activity by Tier and/or engine age would bring emission factors closer to real-life fleet values.
- Similarly, studies providing additional insight on how engine efficiency changes over time could provide even more refined emission factors as determined by age instead of Tier.
- Class II and III railroads are not required to submit R-1 reports; consequently, their vital contribution to the freight network is not well-represented in publicly available data. More detailed activity information for short line and regional railroads would improve emissions estimates, particularly if track-level or local activity can be obtained.
- Switch yard emissions continue to be a weak point in emission inventory development. Yard-specific data, such as engine counts, engine age(s), hours of operation, and fuel use have improved estimates; but these data elements are not available for all yards and are particularly sparse for Class II and III and passenger rail yards.
- Amtrak operates diesel, electric, and dual-mode (diesel or electric) locomotives at varying levels and in different regions. Insight from Amtrak regarding activity levels by engine type and operations by route would improve both emission estimates and spatial representation of activity.
- Currently it is assumed that all railroad companies within a Class have the same distribution of Tier level engines. It should be noted that each rail company has different locomotive age profiles and therefore should have different fleet Tier-level profiles that reflects the investments these companies are making in efficiency and account for emission reductions associated with the use of higher Tier locomotives. For future inventories these companies should be approached for data on their fleet age/Tier level.
- HAP profiles have not been reviewed in some time. New data derived from testing and/or revised methodology could provide more accurate speciation profiles than the profile used for the last several inventory cycles.