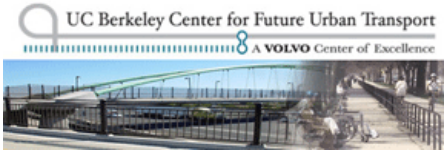

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Title:
Life-cycle Energy and Emissions Inventories for Motorcycles, Diesel Automobiles, School Buses, Electric Buses, Chicago Rail, and New York City Rail

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Abstract:
The development of life-cycle energy and emissions factors for passenger transportation modes is critical for understanding the total environmental costs of travel. Previous life-cycle studies have focused on the automobile given its dominating share of passenger travel and have included only few life-cycle components, typically related to the vehicle (i.e., manufacturing, maintenance, end-of-life) or fuel (i.e., extraction, refining, transport). Chester (2009) provides the first comprehensive environmental life-cycle assessment of not only vehicle and fuel components but also infrastructure components for automobiles, buses, commuter rail systems, and aircraft. Many processes were included for vehicles (manufacturing, active operation, inactive operation, maintenance, insurance), infrastructure (construction, operation, maintenance, parking, insurance), and fuels (production, distribution). The vehicles inventoried were sedans, pickups, SUVs, urban diesel buses, light rail (San Francisco's Muni Metro and Boston's Green Line, both electric), heavy rail (San Francisco Bay Area's BART and Caltrain), and aircraft (small, medium, and large-sized planes are disaggregated). Given the methodological framework in Chester (2009), the question of applicability of these systems to other U.S. modes, and the data availability of other modes, is extended in this study to motorcycles, light duty diesel vehicles, school buses, electric buses, Chicago commuter rail modes, and New York City commuter rail modes.

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Life-cycle Energy and Emissions Inventories for Motorcycles, Diesel Automobiles, School Buses, Electric Buses, Chicago Rail, and New York City Rail

Mikhail Chester and Arpad Horvath

WORKING PAPER
UCB-ITS-VWP-2009-2

UC Berkeley Center for Future Urban Transport
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May 2009

Life-cycle Energy and Emissions Inventories for Motorcycles, Diesel Automobiles, School Buses, Electric Buses, Chicago Rail, and New York City Rail

Supplemental Findings for:

Environmental Life-cycle Assessment of Passenger Transportation Modes in the U.S.

May 2009

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Table of Contents

List of Tables

List of Figures

List of Acronyms

2C	2-cylinder
4C	4-cylinder
BART	Bay Area Rapid Transit Rail System
CA	California
CO	Carbon Monoxide
CR	Commuter Rail
EC	Emissions Control
GGE	Greenhouse Gas Equivalence (CO_2e)
GHG	Greenhouse Gas
IL	Chicago
LDD	Light Duty Diesel
LDDT	Light Duty Diesel Truck (can refer to an SUV or pickup)
LDDV	Light Duty Diesel Vehicle (typically refers to a small automobile similar to a sedan)
LRT	Light Rail Transit
MA	Massachusetts
MC	Motorcycle
NJ	New Yersey
NO_X	Nitrogen Oxides
NY	New York
NYC	New York City
PMT	Passenger Miles Traveled
PM_X	Particulate Matter (the X subscript denotes the particle diameter in μm)
SF	San Francisco
SFBA	San Francisco Bay Area
SO_2	Sulfur Dioxide
SUV	Sport Utility Vehicles
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compounds

1 Background

The development of life-cycle energy and emissions factors for passenger transportation modes is critical for understanding the total environmental costs of travel. Previous life-cycle studies have focused on the automobile given its dominating share of passenger travel and have included only few life-cycle components, typically related to the vehicle (i.e., manufacturing, maintenance, end-of-life) or fuel (i.e., extraction, refining, transport) (MacLean 1998, Cobas-Flores 1998, Sullivan 1998). Chester (2009) provides the first comprehensive environmental life-cycle assessment of not only vehicle and fuel components but also infrastructure components for automobiles, buses, commuter rail systems, and aircraft. Many processes were included for vehicles (manufacturing, active operation, inactive operation, maintenance, insurance), infrastructure (construction, operation, maintenance, parking, insurance), and fuels (production, distribution) in Chester (2009). The vehicles inventoried were sedans, pickups, SUVs, urban diesel buses, light rail (San Francisco's Muni Metro and Boston's Green Line, both electric), heavy rail (San Francisco Bay Area's BART and Caltrain), and aircraft (small, medium, and large-sized planes are disaggregated). Given the methodological framework in Chester (2009), the question of applicability of these systems to other U.S. modes, and the data availability of other modes, is extended in this study to motorcycles, light duty diesel vehicles, school buses, electric buses, Chicago commuter rail modes, and New York City commuter rail modes.

The onroad and rail modes evaluated here are chosen primarily because of data availability. While life-cycle factors are critical in understanding the full environmental costs of passenger travel, vehicle operational "tail-pipe" factors are often the dominating contributor to particular components. For example, Chester (2009) showed that while emissions of CO, SO_2, VOCs, and PM_{10} may be dominated by non-vehicle operation factors such as roadway construction, vehicle manufacturing, or fuel production for automobiles, around 60%-70% of energy consumption and greenhouse gas (GHG) emissions are attributed to fuel combustion. This is important because high quality fuel combustion factors for onroad modes are critical for life-cycle assessments and the EPA Mobile 6.2 emissions modeling software provides these factors for motorcycles, light duty diesel vehicles, and school buses (EPA 2003). Additionally, electric buses are included based on the San Francisco Muni system. The creation of life-cycle environmental factors for these modes will provide for improved cross-comparisons of modal choices. Questions related to the use of diesel automobiles versus conventional gasoline automobiles linger and the creation of life-cycle factors for these modes will provide additional clarification for overall environmental performance. The assessment of Chicago and New York City rail systems is

performed because of the transit-rich options of the regions. Adding the Chicago and New York City rail system inventories to the San Francisco Bay Area inventories already computed will provide critical data for three transit-oriented cities that will allow for regional assessments (the preliminary regional assessment is performed in and is currently being updated based on the results in this document). The diversity of rail options in these cities is greater than most other metropolitan regions and the life-cycle inventories will illuminate the critical characteristics of the systems that makes one outperform the others. The rail systems inventoried are the Chicago Metro, Chicago Metra commuter rail, New York City's metro, the New York/New Jersey PATH metro, Newark's LRT, and New York City's Metro North commuter rail.

2 Methodology

While vehicle, infrastructure, and fuel components are captured in all inventories, two somewhat different approaches are used to determine the environmental performance of components for the onroad and rail modes. The baseline comparison year is 2005 for all vehicles. Tier 2 low sulfur fuel programs are implemented and reflected in emissions outputs.

2.1 Onroad Inventories Methodology

The approach used to guide the estimation of the onroad inventories follows that of Chester (2009). Vehicle manufacturing, maintenance, and insurance are estimated with EIOLCA (2009). The motorcycles are represented by the 4-cylinder Yamaha VMAX ($16,300), 2-cylinder Harley Davidson Fat Boy ($17,500), and Kawasaki ZX-14 ($11,600) (Cycle World 2009). These models are chosen because they are assumed to be a good representation of the ranges in motorcycles. The 4-cylinder model represents muscle and touring bikes, the 2-cylinder model captures most cruisers, and the sports bike highlights the top performance and power niche. All dollars are year 2005 unless otherwise stated. Light duty diesel sedans and pickups are assumed to be priced $3000 more than their conventional gasoline counterparts. The school bus is given a price of $87,500 and electric bus $350,000 (which is about $50,000 greater than diesel urban buses but less than the new hybrid buses in San Francisco with a price of $500,000) (Edmunds 2009, SFMTA 2009). Motorcycle maintenance costs are assumed to be 50% of the purchase costs over the lifetime of the vehicle (similar to automobiles). Tire maintenance is determined from an assumed $150 cost per tire and a replacement lifetime of 6,000 miles. The diesel automobiles are assumed to have equal maintenance to their conventional gasoline counterparts and

school and electric buses are assumed to have similar maintenance costs to urban buses. Annual insurance costs for the motorcycles are $500 for the 4-cyclinder, $200 for the 2-cylinder, and $1,000 for the sports bike (Lankard 2009). Similar to maintenance costs, diesel autos are assumed to have similar insurance costs to their gasoline counterparts and the school and electric buses to urban buses.

Vehicle operation is evaluated from three components: direct energy use (gasoline, diesel, and electricity), cold start operation, brake wear, tire wear, evaporative VOC losses, and idling (for buses). The 4-cyclinder motorcycle is estimated to achieve a 41 miles per gallon fuel economy, the 2-cylinders 45 miles per gallon, and the sport bike 33 miles per gallon. While fuel economy may vary significantly depending on operating characteristics, these averages were assumed reasonable for typical conditions. Motorcycle emissions were determined from several sources. The importance of catalytic converters to motorcycle emissions was captured through the modeling of an "emission controlled" and "non-emission controlled" 4 and 2-clinder vehicle. There is sparse data on motorcycle emissions in the U.S. likely due to their minor share of VMT. This is not the case with many Asian countries where motorcycles represent a larger fraction of total VMT and the importance of "emission controlled" vehicles is heavily scrutinized. Combining both U.S. and Asian data on emissions from different vehicles, factors for the five motorcycle types were determined (Chen 2003, CITEPA 2005, HD 2005, MacDonald 2005, Tsai 2000). These are 4-cyclinder uncontrolled and emission controlled (EC), 2-cyliner uncontrolled and emission controlled, and a sports bike (evaluated as a 4-cylinder with uncontrolled emissions vehicle). The diesel sedan, diesel pickup, and school bus fuel economies and emissions were determined from EPA (2003). Lastly, the electric bus electricity economy was determined from FTA (2005) electricity consumption data and corresponding San Francisco Bay Area emissions in generation (Deru 2007). Cold start, brake wear, tire wear, and evaporative emission factors were determined from Mobile 6.2 for motorcycles, diesel automobiles, and school buses (EPA 2003). Only the brake and tire wear factors were applied to electric buses from Mobile 6.2's urban diesel bus factors. Given the idling fraction of total energy for the urban diesel bus, the electric buses' fraction of energy consumed was determined.

With the exception of the electric bus, all infrastructure and fuel components are determined from the same methodology described in Chester (2009). For the electric bus, while infrastructure components were computed similarly, fuel production components needed to be determined differently given the use of electricity as a fuel input and not gasoline or diesel. The precombustion effects as well as transmission and distribution effects from the electricity consumed during bus operation are included from electricity generation life-cycle factors (Deru 2007).

All results have been normalized by vehicle lifetime, vehicle miles traveled (VMT), and passenger miles traveled (PMT). This is done to improve transparency of results and present data in multiple functional units which may be desired in future analyses. For light duty diesel vehicles and the electric bus, weights and vehicle lifetimes are assumed equal to their conventional gasoline and diesel urban bus counterparts. Motorcycle weights are determined from Cycle World (2009) while the school bus is estimated to weight 40,000 lbs (25,000 lbs curb weight and 15,000 lbs of passengers). The motorcycle lifetimes are determined from a 75,000 (4 and 2-cylinder) and 60,000 (sport bike) mile lifetime and average yearly VMT (KBB 2009). The school bus lifetime is specified as 15 years which is the suggested replacement time for vehicles (NASDPTS 2002). The average yearly school bus VMT is specified at 11,000 and the electric bus 27,000 (NASDPTS 2002, FTA 2005). While motorcycles average 1.3 passengers, it is assumed that sports bike average one passenger. School buses are assumed to operate at 75% occupancy of 84 seats and the electric bus achieves an average 16 passengers (although both an off-peak of 5 and peak of 40 passengers is shown in the results), the average for the San Francisco Muni system (FTA 2005). These operating characteristics, which are used to normalize to the multiple functional units, are summarized in Table 1.

Table 1 – Onroad Vehicles Critical Operating Characteristics

	Motorcycle (4-cylinder)	Motorcycle (2-cylinder)	Motorcycle (Sport Bike)	LDDV	LDDT	School Bus	Electric Bus
Vehicle Weight (lbs)	500	690	470	3,200	5,200	40,000	25,000
Vehicle Lifetime (yrs)	13	15	20	17	16	15	12
Yearly VMT (mi/yr)	6,000	5,000	3,000	11,000	11,000	11,000	27,000
Average Occupancy	1.3	1.3	1	1.58	1.46	63	16
Yearly PMT (mi/yr)	6,000	5,000	3,000	17,000	16,000	690,000	420,000

All values rounded to two significant digits.

2.2 Rail Inventories Methodology

The rail vehicle, infrastructure, and fuel components are computed with the same methodology as Chester (2009). The addition of the Chicago and New York City rail systems supplements the original Chester (2009) inventory with new modes that are technologically similar to the existing modes. The New York City metro, NY/NJ PATH metro, and Chicago metro are evaluated with the same framework

used to evaluate the San Francisco Bay Area BART system. There are 578 trains operating during the average weekday for New York City, 36 for NY/NJ PATH, and 141 for Chicago compared to BART's 61 (FTA 2005). Infrastructure differences also vary widely between these metro systems. While there are 43 stations in BART's network, there are 468 in the New York City's, 13 in NY/NJ PATH's, and 144 in Chicago's (FTA 2005). Also, track mileage varies from 267 for BART (58% surface, 21% elevated, 21% underground), 835 for New York City (24% surface, 22% elevated, 54% underground), 43 for NY/NJ PATH (53% surface, 8% elevated, 38% underground), and 288 for Chicago (51% surface, 40% elevated, 8% underground) (FTA 2005). The Newark LRT system is evaluated with the same framework as the San Francisco Muni Metro and Boston Green Line. There are 28 Newark LRT trains operating on the average weekday compared against 127 for the Muni Metro and 77 for the Green Line (FTA 2005). The Newark LRT has 17 stations and 99 miles of track (96% surface, 2% elevated, 2% underground) while the Muni Metro and Green Line have 56 and 70 stations and 73 (80% surface, 20% underground) and 78 (77% surface, 5% elevated, 18% underground) miles of track (FTA 2005). The New York City and Chicago commuter rail systems are evaluated with the same framework as the San Francisco Bay Area's Caltrain. New York City and Chicago operate 140 weekday trains each on average compared to Caltrain's 19 (FTA 2005). There are 109 and 231 stations for New York City and Chicago compared against 33 for Caltrain (FTA 2005). Track mileage is 805 (98% surface, 1% elevated, 1% underground) and 1,144 (100% surface) for New York City and Chicago while 137 (97% surface, 3% elevated) for Caltrain (FTA 2005). The manufacturing energy and emissions are estimated from the life-cycle assessment software SimaPro (SimaPro 2006). Propulsion, idling, and auxiliary energy are assumed to have the same fractional breakdown as the Chester (2009) counterparts. Maintenance was also determined from SimaPro (2006) while cleaning (vacuuming and mopping) and flooring replacement were determined from flooring types (carpeting or plastic composite). Using NTD reported employee costs, employee vehicle and infrastructure insurance costs are determined and coupled with energy and emissions estimates for the "Insurance Carriers" sector of EIOLCA (2009).

Based on the system type (metro, commuter rail, light rail), the number of stations, and the length of track types (surface, underground, elevated), infrastructure construction energy and emissions are determined. For example, the Newark LRT's station construction requirements are assumed equivalent to the Boston Green Line's. The track construction energy and emissions are estimated from basic materials such as steel, concrete, and wood. Track maintenance is assumed to be 5% of initial construction requirements. Using estimates from the Chester (2009) systems, station energy

consumption (and upstream electricity production emissions) are computed for lighting, escalators, and train control systems. Station life-time maintenance is assumed to be 5% of construction requirements, major renovations (reconstruction) are included based on expected facility lifetimes, and station cleaning is determined from mopping requirements and chemical cleaner production. Using the Pavement Life-cycle Assessment Tool for Environmental and Economic Effects, parking space construction and maintenance energy and emissions are computed (PaLATE 2004). While the New York City metro, NY/NJ PATH metro, and Newark LRT systems do have direct control over parking facilities, New York City commuter rail (14,000 spaces), Chicago commuter rail (7,200 spaces), and the Chicago metro (5,700 spaces) do (NYMTA 2009, Metra 2005, CTA 2008).

The fuel production and distribution effects are captured for both diesel and electric vehicles. The production of diesel fuels is capture with EIOLCA (2009) and electricity Deru (2007). The New York City electric modes are specified with the New York state mix and the Chicago electric modes with the Illinois mix.

The normalization of results per vehicle lifetime, VMT, and PMT are based on particular operating characteristics of each train in each system. All vehicles are assumed to have a lifetime of 30 years with the exception of the Newark LRT trains specified at 27 years (the same as the San Francisco Muni Metro). The total yearly VMT have a broad range due to the functionality and level of service achieved by each system (FTA 2005). The average occupancies which are determined from the National Transit Database are used to determine yearly PMT (FTA 2005). These factors are summarized in Table 2.

Table 2 – Rail Vehicles Critical Operating Characteristics (per Train)

	NYC Metro	NY/NJ PATH Metro	Newark Light Rail	NYC Commuter Rail	Chicago Commuter Rail	Chicago Metro
Vehicle Lifetime (yrs)	30	30	27	30	30	30
Yearly VMT (mi/yr)	67,000	53,000	74,000	64,000	45,000	88,000
Average Occupancy	217	158	24	173	232	91
Yearly PMT (mi/yr)	15,000,000	8,400,000	1,800,000	11,000,000	10,000,000	8,100,000

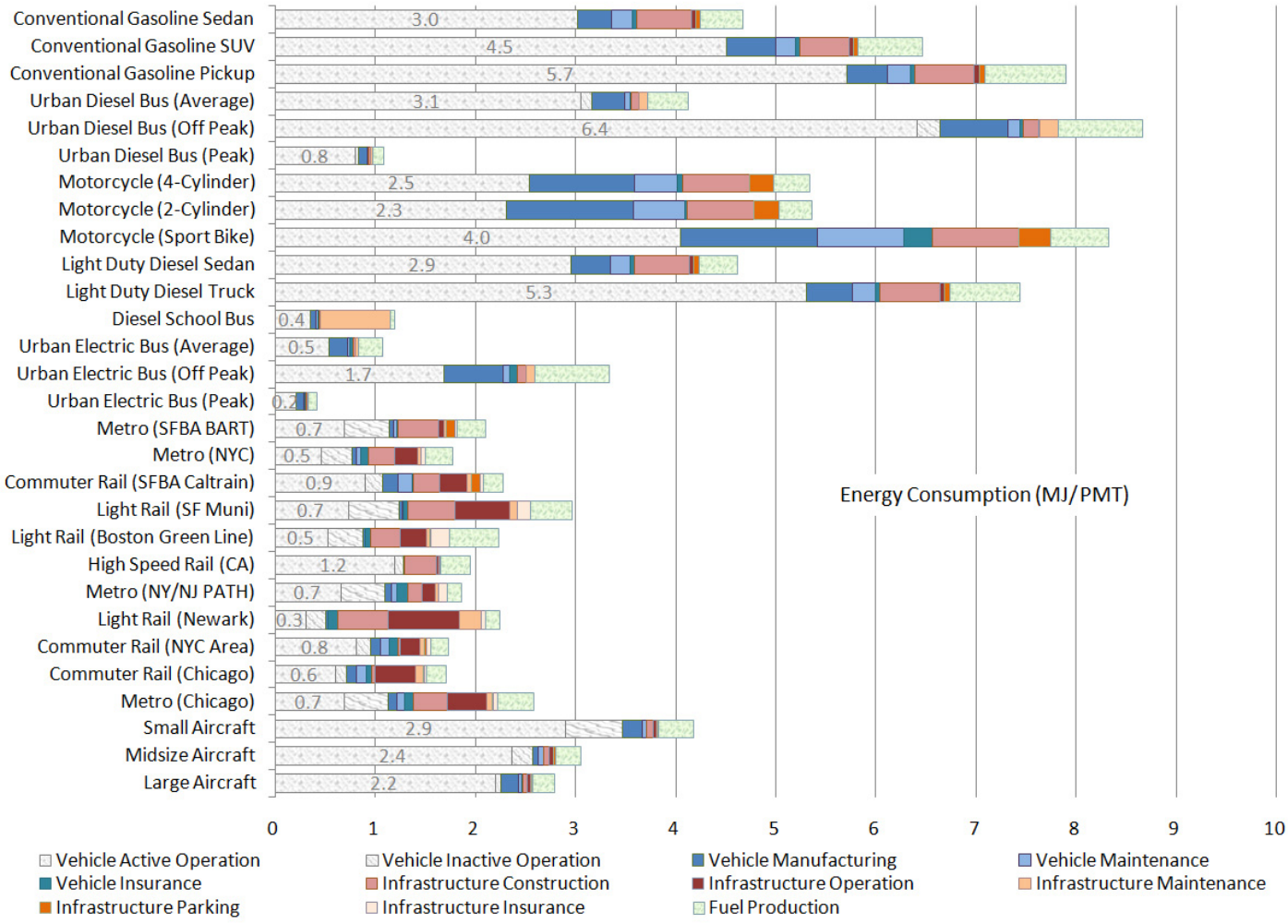
All values rounded to two significant digits.

3 Modal Energy and Emissions Inventories Summary

3.1 Energy Consumption and Greenhouse Gas Emissions

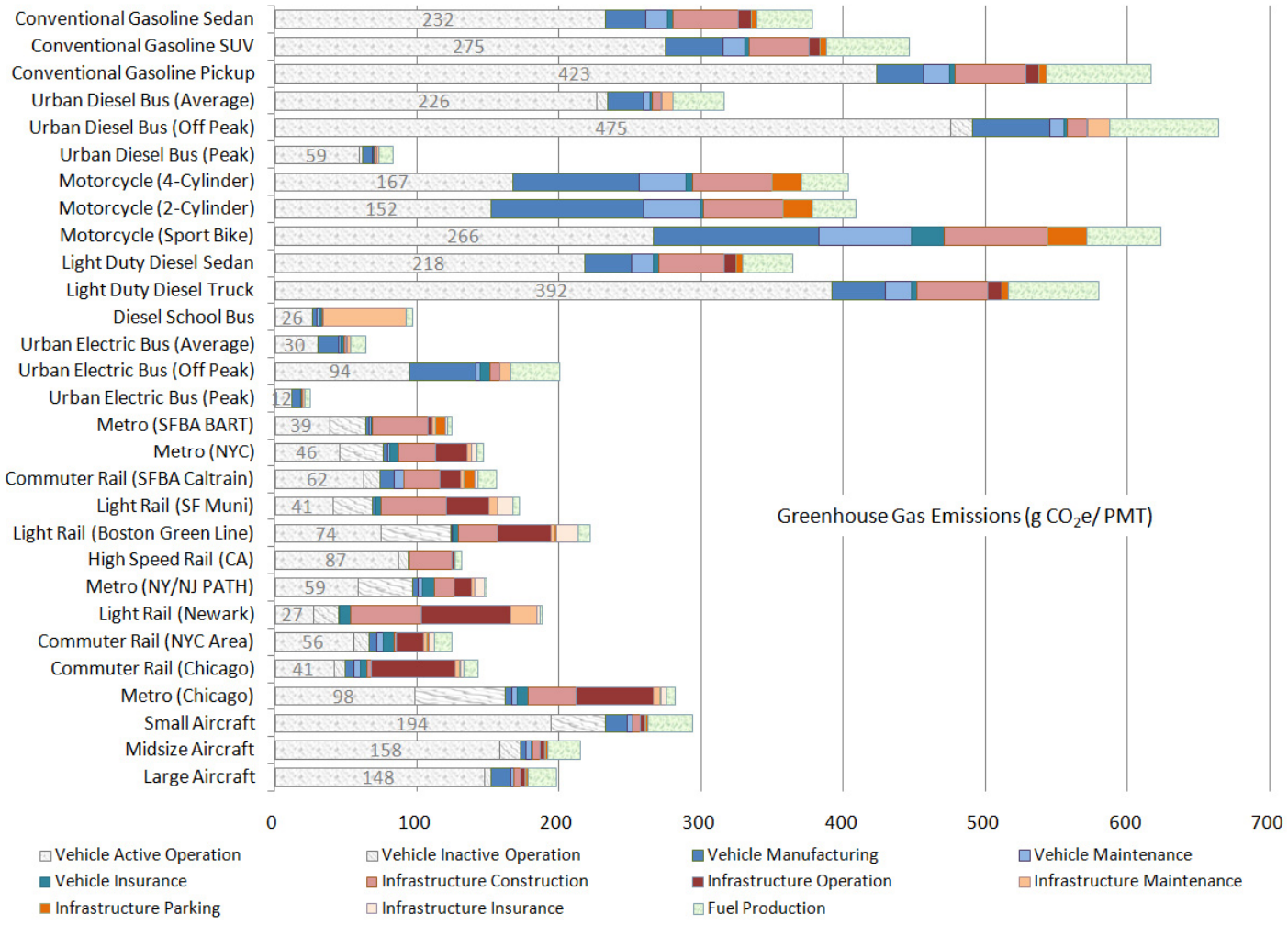
Energy consumption grouped into major life-cycle components are shown in Figure 1. Both the modes from Chester (2009) and those inventoried in this study are included for comparative purposes.

Figure 1 – Summary Modal Energy Consumption in MJ/PMT



The implementation of an emissions control device does not change the energy or GHG performance of motorcycles significantly. Modal GHG performance is shown in Figure 2.

Figure 2 – Summary Modal GHG Emissions in g CO_2e/PMT



3.2 SO_2, NO_X, VOCs, PM_{10}, and CO Emissions

Figure 3 through Figure 8 summarize the SO_2, NO_X, VOC, PM_{10}, and CO emissions per PMT. For these pollutants, "active operation" emissions are further disaggregated into warm and cold running modes to illustrate the contributions of emissions when the catalytic converter is not fully operational.

Figure 3 – Summary Modal SO_2 Emissions in mg/PMT

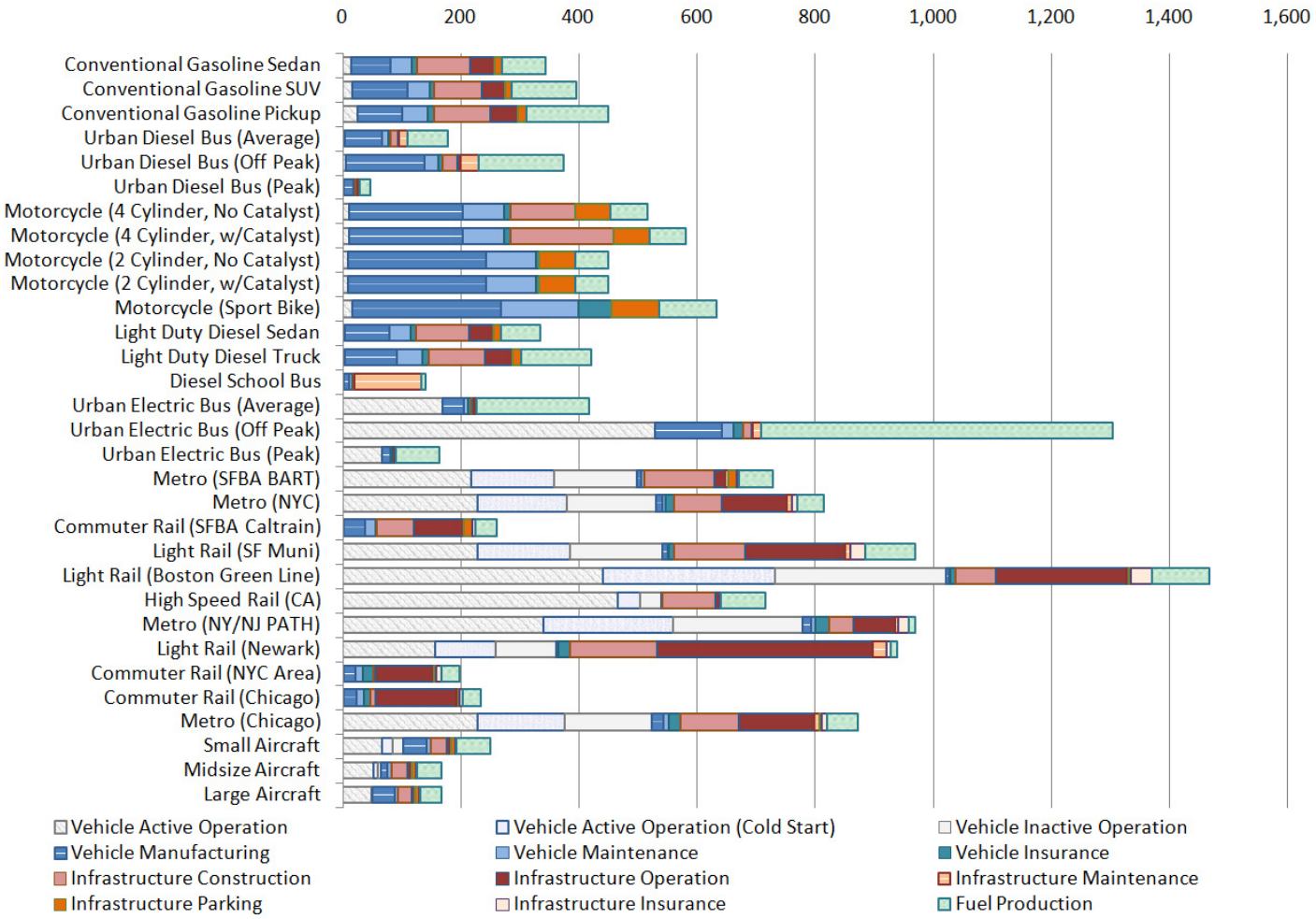


Figure 4 – Summary Modal NO_X Emissions in mg/PMT

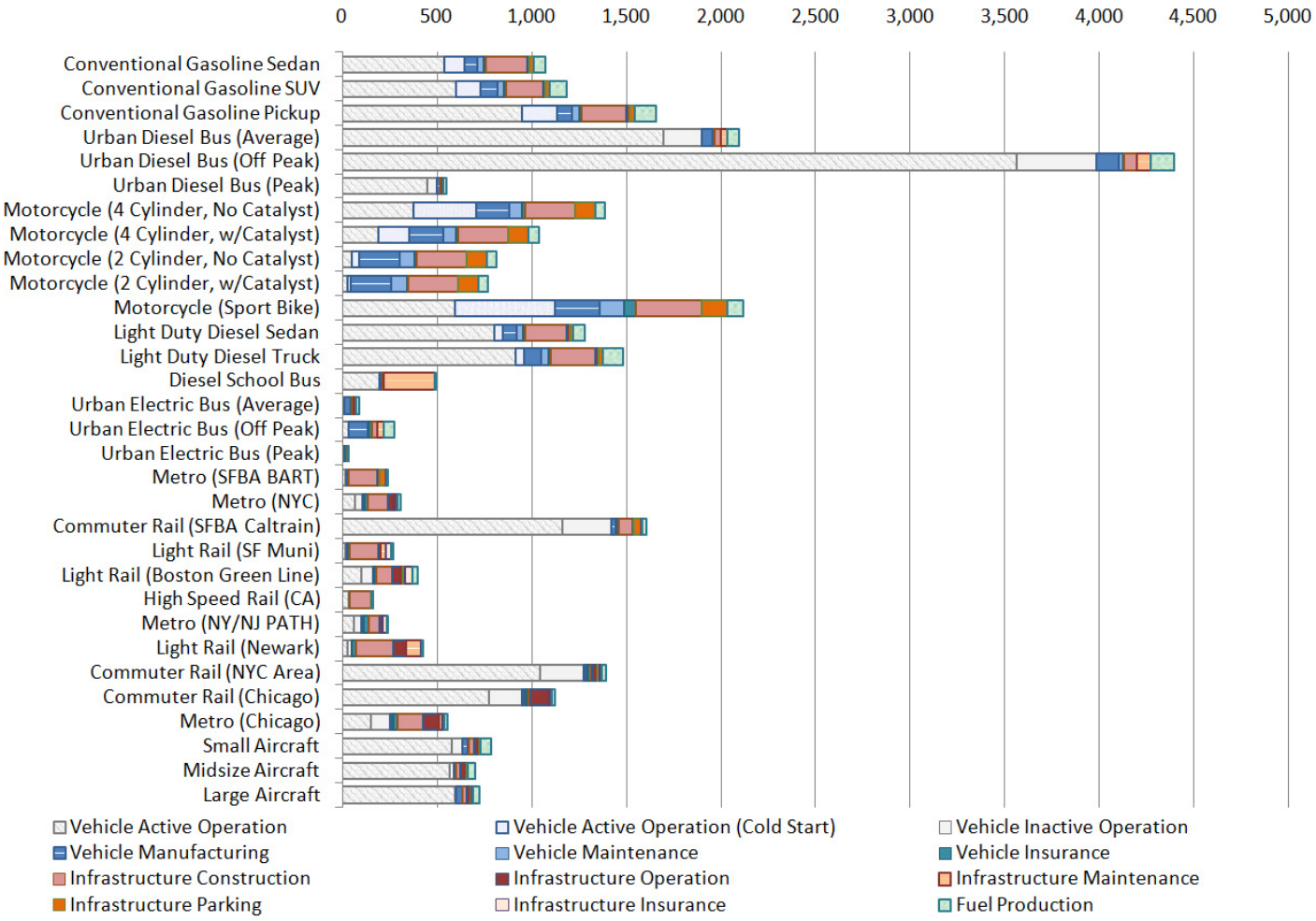


Figure 5 – Summary Modal VOC Emissions in mg/PMT

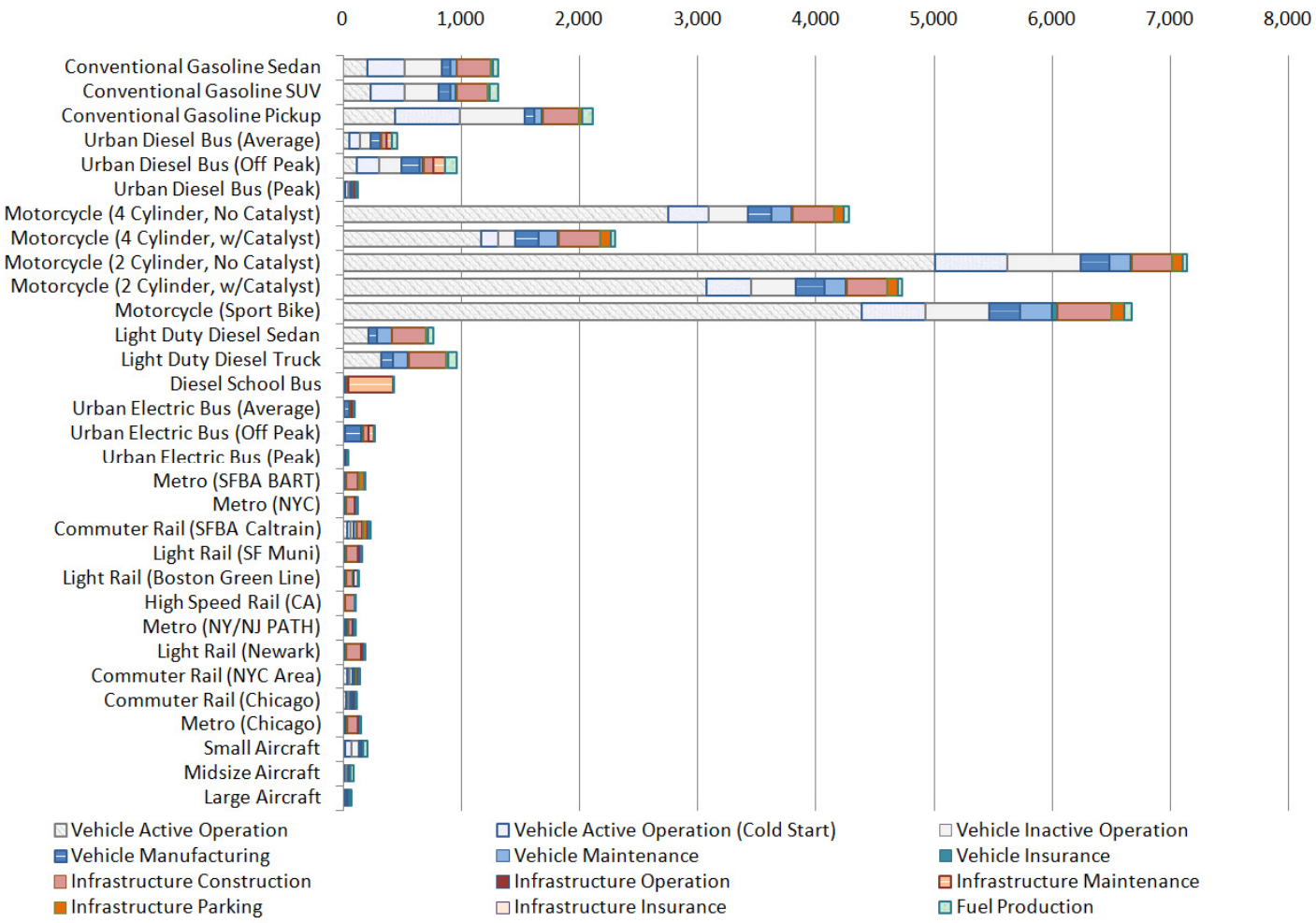
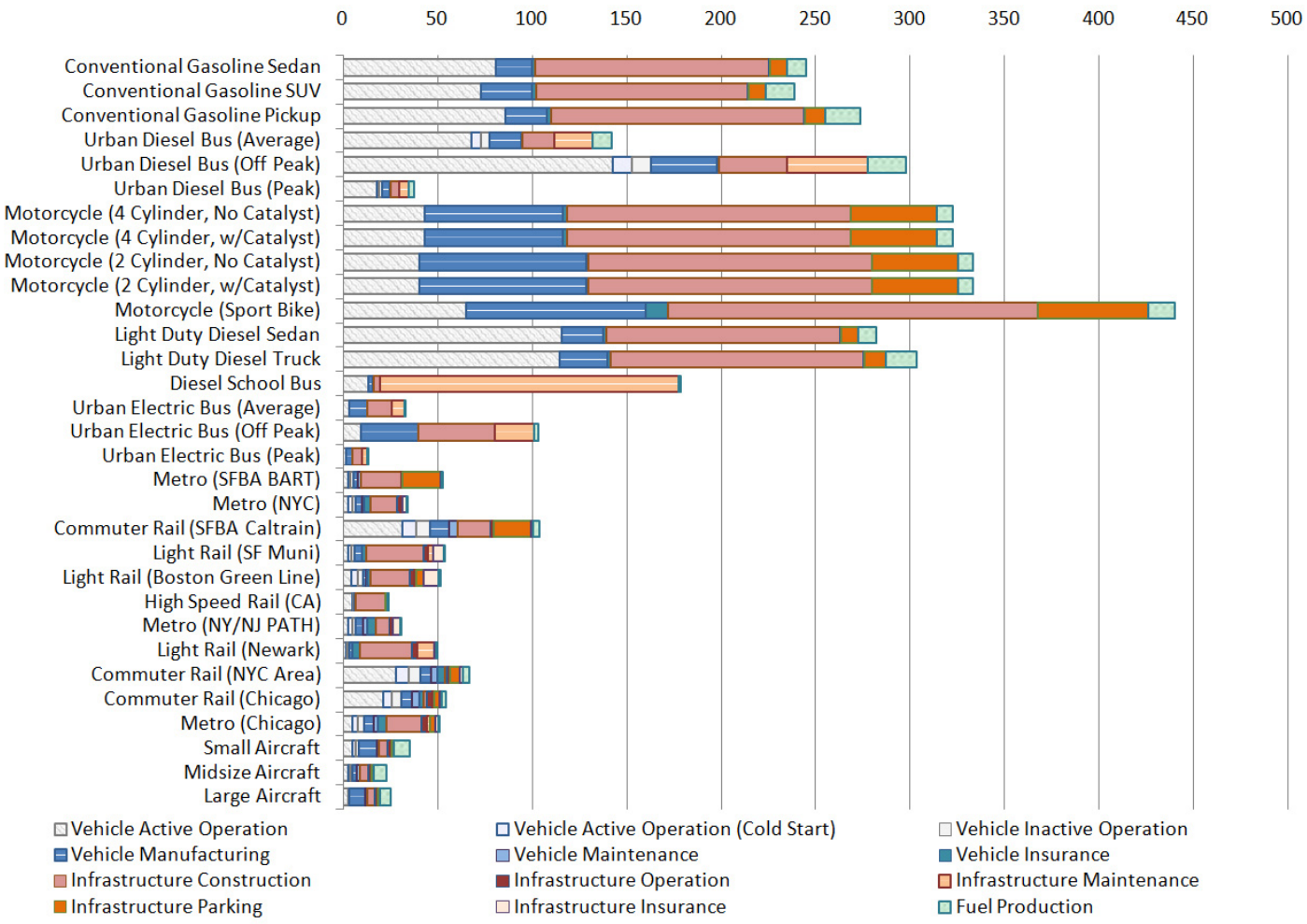


Figure 6 – Summary Modal PM_{10} Emissions in mg/PMT



There is a range in the per-PMT emissions from the automobiles and motorcycles to the buses, trains, and aircraft. While the per-VMT emissions for all modes may show smaller variations, the accounting of the number of passengers results in buses, trains, and aircraft having much lower per-PMT CO emissions than automobiles and motorcycles. This is reflected in Figure 7 and Figure 8.

Figure 7 – Summary Automobile and Motorcycle CO Emissions in mg/PMT

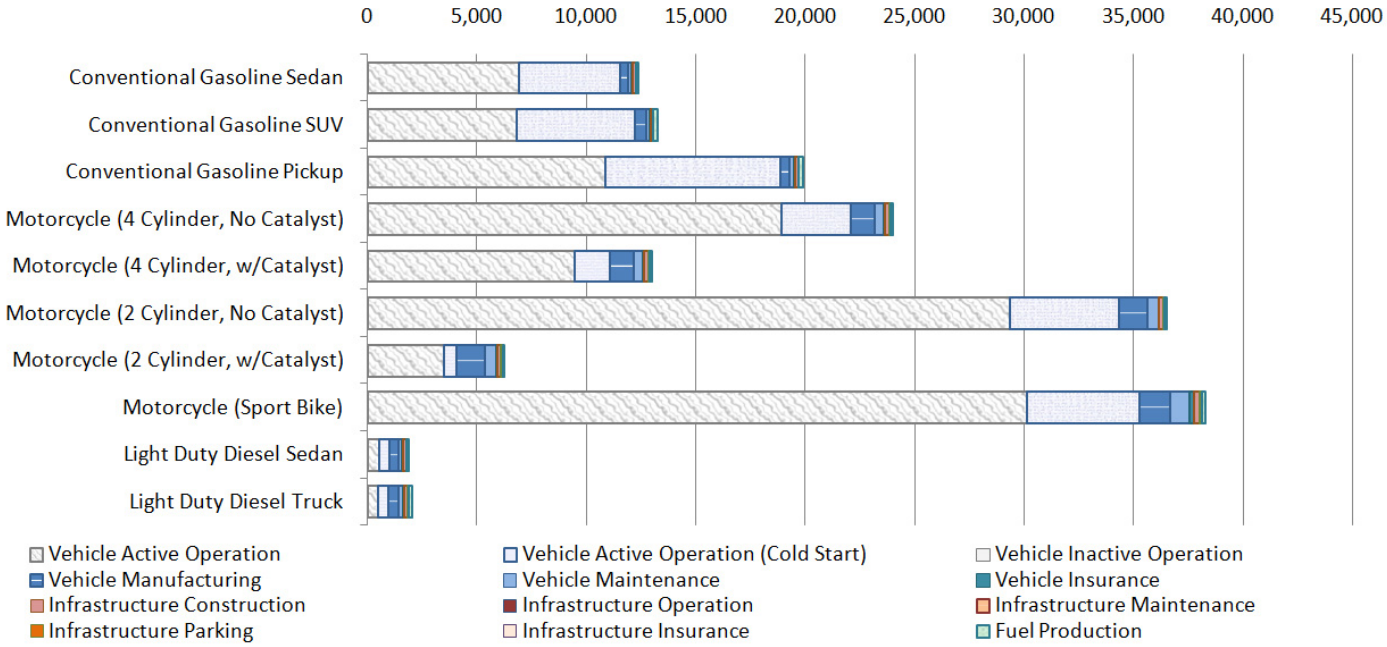
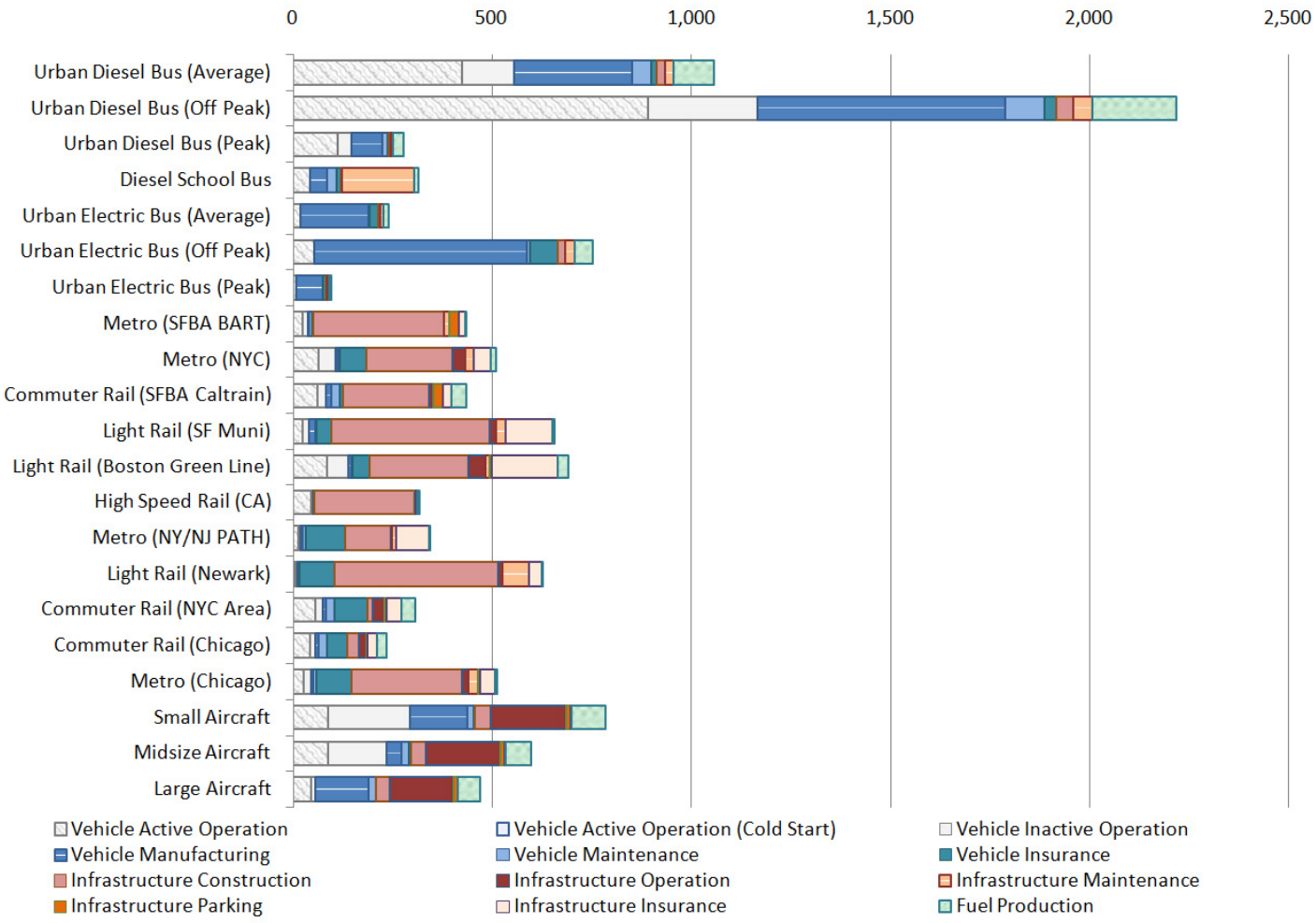


Figure 8 – Summary Bus, Rail and Aircraft CO Emissions in mg/PMT



4 Discussion

The total life-cycle energy consumption and emissions are often dominated by a few critical processes for each mode. Many of the contributions are explained in Chester (2009) where similar life-cycle component processes are responsible for the larger energy consumption or emissions in the total inventories. These components are discussed in extensive detail in Chester (2009) and will be generally discussed in this section.

For energy and emissions, the onroad modes are heavily influenced by vehicle manufacturing and maintenance, infrastructure construction, and fuel production. The electricity use in vehicle and parts production as well as the fuels needed to transport parts and materials are the primary energy and GHG contributors to vehicle manufacturing and maintenance. The dominating share of light duty vehicle travel on roadways increases the allocation of roadway energy and GHG emissions to the infrastructure construction phase. The energy requirements and resulting GHG emissions needed to extract, refine, and transport fuels is significant. This is not the case for just conventional gasoline and diesel vehicles but also for the electric bus. The energy required to produce primary fuels for fossil-based electricity generation facilities results in large contributions for this mode. School buses show large contributions from infrastructure maintenance components. School buses are estimated at around 70% of the bus fleet and although they average fewer VMT than urban passenger buses, their impact on local roadways in particular is significant (FHWA 1997). Attributing this maintenance to buses results in more energy and GHG emissions required to maintain roads due to buses than the actual bus creates itself. The large non-operational shares for motorcycles are due to the large process requirements and relatively few PMT served. For example, it takes roughly the same amount of energy to produce a motorcycle as it does an automobile (this may be because of economies of scale or the extra requirements to produce specialty parts) but motorcycles service roughly one-third the PMT as the automobile modes over the vehicle's lifetime. The SO_2, NO_X, VOC, PM_{10}, and CO emissions are produced from several different processes across life-cycle components. SO_2 is produced primarily in electricity generation. Similar to Chester (2009), the SO_2 emitted from electricity generation in life-cycle components dominates total emissions due to low fuel sulfur contents in direct combustion. The SO_2 emissions from electricity requirements in aggregate production for infrastructure construction, vehicle manufacturing, and fuel production are strong contributors across all modes. NO_X emissions are mostly attributable to diesel truck and equipment use, often in material or parts transport. While VOCs are dominated by the vehicle operation phase, the releases during asphalt placement during roadway construction are non-negligible.

The vehicle manufacturing and roadway construction phases show dominating contributions to total PM_{10} emissions. Additionally, parking construction has significant contributions for automobiles as does infrastructure maintenance for buses. While CO emissions for autos are mostly from vehicle operation, the emissions from truck transportation in vehicle manufacturing contribute heavily to bus modes.

The infrastructure construction, infrastructure operation, and fuel production components are the strongest influence on rail energy consumption and GHG emissions. The massive material requirements (particularly concrete) results in significant energy consumption for building rail stations and tracks. Infrastructure operation includes station lighting, escalators, and train control, all of which consume large quantities of electricity considering continuously draw electricity for a large part of the day. The energy and corresponding GHG emissions of primary fuels extraction and processing for electricity generation results in significant contributions from the fuel production phase. For the other emissions, similar processes are responsible for large life-cycle contributions but the large physical size of rail infrastructure given the PMT served pronounces the contributions from infrastructure components. SO_2 in electricity generation again shows in the infrastructure operation component for station power. The electricity required in concrete production results in a non-negligible contribution for the infrastructure construction component of some modes. While NO_X in diesel trucks and equipment use dominates some rail modes, for commuter rail systems, vehicle operation factors dominate. This is due to direct combustion of diesel fuel by these vehicles and produces much larger vehicle operation emissions than electric modes. VOC and PM_{10} emissions are relatively small for rail modes but can be dominated by the release of organic components in cement production and fugitive emissions in aggregate production for infrastructure construction.

The detailed energy and emissions life-cycle component factors for each mode are found at the end of this document in the Supporting Data section:

Onroad Inventories
Motorcycle (4 Cylinder, no Emissions Control) Life-cycle Inventory (Page 27)
Motorcycle (4 Cylinder, with Emissions Control) Life-cycle Inventory (Page 29)
Motorcycle (2 Cylinder, no Emissions Control) Life-cycle Inventory (Page 31)
Motorcycle (2 Cylinder, with Emissions Control) Life-cycle Inventory (Page 33)
Motorcycle (Sports Bike) Life-cycle Inventory (Page 35)
Light Duty Diesel Sedan Life-cycle Inventory (Page 37)
Light Duty Diesel Truck Life-cycle Inventory (Page 39)
School Bus Life-cycle Inventory (Page 41)
Electric Bus Life-cycle Inventory (Page 43)

Rail Inventories
New York City Metro Life-cycle Inventory (Page 45)
NY/NJ PATH Metro Life-cycle Inventory (Page 48)
Newark Light Rail Life-cycle Inventory (Page 51)
New York City Commuter Rail Life-cycle Inventory (Page 54)
Chicago Commuter Rail Life-cycle Inventory (Page 57)
Chicago Metro Life-cycle Inventory (Page 60)

These life-cycle inventories highlight the importance of energy and emissions inventories for transportation modes that include components beyond vehicle direct energy use. The energy and GHG emissions in vehicle operation are between 10% and 70% of the total inventory showing that even at its largest contribution, non-operational components have significant contributions. For SO_2, NO_X, VOCs, PM_{10}, and CO emissions, the results are even stronger. It is often the case that the vast majority of emissions of these pollutants occur outside of the vehicle operation phase. The uncertainty of data used and the methodology applied follows the same assessment as in Chester (2009). While the life-cycle inventories presented are valuable, they do not delve into impact assessment (with the exception of GHG emissions). These inventories should provide an improved dataset for evaluating GHG, human health, ecologic, and other impact categories. The importance of proper attribution of energy consumption and emissions is critical in well-formed policy and decision making.

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6 Supporting Data for Supplemental Modes

The following subsections provide the life-cycle component results for each mode. All functional units are reported (per Vehicle Lifetime, VMT, and PMT).

6.1 Motorcycle (4 Cylinder, no Emissions Control) Life-cycle Inventory

Table 3 – Motorcycle (4 Cylinder, no Emissions Control) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	120 GJ	1,500 kJ	1,200 kJ
	GHG	9.8 mt GGE	130 g GGE	100 g GGE
	SO_2	21 kg	280 mg	220 mg
	CO	120 kg	1,600 mg	1,200 mg
	NO_x	20 kg	260 mg	200 mg
	VOC	22 kg	290 mg	220 mg
	PM_{10}	8.0 kg	110 mg	82 mg
	Pb	43 g	570 µg	440 µg
V, Operation (Running)	Energy	250 GJ	3,300 kJ	2,500 kJ
	GHG	16 mt GGE	220 g GGE	170 g GGE
	SO_2	0.93 kg	12 mg	9.5 mg
	CO	1,800 kg	25,000 mg	19,000 mg
	NO_x	36 kg	490 mg	370 mg
	VOC	270 kg	3,600 mg	2,700 mg
	PM_{10}	2.9 kg	39 mg	30 mg
	Pb	-	-	-
V, Operation (Start)	CO	310 kg	4,200 mg	3,200 mg
	NO_x	32 kg	430 mg	330 mg
	VOC	38 kg	500 mg	380 mg
V, Operation (Tire)	PM_{10}	0.30 kg	4.0 mg	3.1 mg
V, Operation (Brake)	PM_{10}	0.94 kg	13 mg	9.6 mg
V, Automotive Repair	GHG	380 g GGE	5,100 µg GGE	3,900 µg GGE
V, Automotive Repair	VOC	8.8 kg	120 mg	90 mg
V, Evaporative Losses	VOC	33 kg	440 mg	340 mg
V, Tire Production	Energy	23 GJ	310 kJ	240 kJ
	GHG	1.7 mt GGE	22 g GGE	17 g GGE
	SO_2	3.0 kg	40 mg	31 mg
	CO	23 kg	310 mg	240 mg
	NO_x	3.1 kg	42 mg	32 mg
	VOC	4.0 kg	53 mg	41 mg
	PM_{10}	-	-	-
	Pb	1,800 g	23,000 µg	18,000 µg
V, Maintenance	Energy	20 GJ	270 kJ	210 kJ
	GHG	1.7 mt GGE	23 g GGE	18 g GGE
	SO_2	4.3 kg	58 mg	44 mg
	CO	21 kg	280 mg	220 mg
	NO_x	3.9 kg	52 mg	40 mg
	VOC	4.0 kg	53 mg	41 mg
	PM_{10}	0.011 kg	0.14 mg	0.11 mg
	Pb	1,300 g	17,000 µg	13,000 µg
V, Fixed Costs / Insurance	Energy	5.3 GJ	71 kJ	54 kJ
	GHG	0.43 mt GGE	5.8 g GGE	4.4 g GGE
	SO_2	1.1 kg	14 mg	11 mg
	CO	4.8 kg	64 mg	49 mg
	NO_x	1.2 kg	16 mg	12 mg
	VOC	0.89 kg	12 mg	9.1 mg
	PM_{10}	0.23 kg	3.0 mg	2.3 mg
	Pb	-	-	-

Table 4 – Motorcycle (4 Cylinder, no Emissions Control) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	65 GJ	860 kJ	670 kJ
	GHG	5.4 mt GGE	73 g GGE	56 g GGE
	SO_2	11 kg	140 mg	110 mg
	CO	17 kg	230 mg	170 mg
	NO_x	26 kg	350 mg	270 mg
	VOC	34 kg	450 mg	350 mg
	PM_{10}	15 kg	200 mg	150 mg
	Pb	0.0032 kg	0.042 mg	0.032 mg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	380 MJ	5.0 kJ	3.8 kJ
	GHG	28 kg GGE	370 mg GGE	290 mg GGE
	SO_2	13 mg	0.17 µg	0.13 µg
	CO	100 mg	1.4 µg	1.0 µg
	NO_x	37 mg	0.50 µg	0.38 µg
	VOC	40 mg	0.53 µg	0.41 µg
	PM_{10}	7.7 mg	0.10 µg	0.079 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	4.8 GJ	64 kJ	49 kJ
	GHG	1.0 mt GGE	13 g GGE	10 g GGE
	SO_2	5.0 kg	67 mg	52 mg
	CO	0.49 kg	6.5 mg	5.0 mg
	NO_x	1.7 kg	22 mg	17 mg
	VOC	0.043 kg	0.57 mg	0.44 mg
	PM_{10}	0.055 kg	0.74 mg	0.57 mg
	Pb	0.000079 kg	0.0010 mg	0.00081 mg
I, Parking	Energy	24 GJ	320 kJ	250 kJ
	GHG	2.0 mt GGE	27 g GGE	21 g GGE
	SO_2	5.9 kg	79 mg	61 mg
	CO	8.6 kg	110 mg	88 mg
	NO_x	11 kg	140 mg	110 mg
	VOC	8.5 kg	110 mg	87 mg
	PM_{10}	4.4 kg	59 mg	45 mg
	Pb	0.0011 kg	0.015 mg	0.012 mg
F, Refining & Distribution	Energy	35 GJ	470 kJ	360 kJ
	GHG	3.2 mt GGE	43 g GGE	33 g GGE
	SO_2	6.0 kg	80 mg	62 mg
	CO	8.8 kg	120 mg	90 mg
	NO_x	5.1 kg	68 mg	53 mg
	VOC	3.8 kg	51 mg	39 mg
	PM_{10}	0.84 kg	11 mg	8.6 mg
	Pb	-	-	-

6.2 Motorcycle (4 Cylinder, with Emissions Control) Life-cycle Inventory

Table 5 – Motorcycle (4 Cylinder, with Emissions Control) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	120 GJ	1,500 kJ	1,200 kJ
	GHG	9.8 mt GGE	130 g GGE	100 g GGE
	SO_2	21 kg	280 mg	220 mg
	CO	120 kg	1,600 mg	1,200 mg
	NO_x	20 kg	260 mg	200 mg
	VOC	22 kg	290 mg	220 mg
	PM_{10}	8.0 kg	110 mg	82 mg
	Pb	43 g	570 µg	440 µg
V, Operation (Running)	Energy	250 GJ	3,300 kJ	2,500 kJ
	GHG	16 mt GGE	220 g GGE	170 g GGE
	SO_2	0.93 kg	12 mg	9.5 mg
	CO	920 kg	12,000 mg	9,500 mg
	NO_x	18 kg	240 mg	190 mg
	VOC	110 kg	1,500 mg	1,200 mg
	PM_{10}	2.9 kg	39 mg	30 mg
	Pb	-	-	-
V, Operation (Start)	CO	160 kg	2,100 mg	1,600 mg
	NO_x	16 kg	220 mg	170 mg
	VOC	16 kg	210 mg	160 mg
V, Operation (Tire)	PM_{10}	0.30 kg	4.0 mg	3.1 mg
V, Operation (Brake)	PM_{10}	0.94 kg	13 mg	9.6 mg
V, Automotive Repair	GHG	380 g GGE	5,100 µg GGE	3,900 µg GGE
V, Automotive Repair	VOC	8.8 kg	120 mg	90 mg
V, Evaporative Losses	VOC	14 kg	190 mg	140 mg
V, Tire Production	Energy	23 GJ	310 kJ	240 kJ
	GHG	1.7 mt GGE	22 g GGE	17 g GGE
	SO_2	3.0 kg	40 mg	31 mg
	CO	23 kg	310 mg	240 mg
	NO_x	3.1 kg	42 mg	32 mg
	VOC	4.0 kg	53 mg	41 mg
	PM_{10}	-	-	-
	Pb	1,800 g	23,000 µg	18,000 µg
V, Maintenance	Energy	20 GJ	270 kJ	210 kJ
	GHG	1.7 mt GGE	23 g GGE	18 g GGE
	SO_2	4.3 kg	58 mg	44 mg
	CO	21 kg	280 mg	220 mg
	NO_x	3.9 kg	52 mg	40 mg
	VOC	4.0 kg	53 mg	41 mg
	PM_{10}	0.011 kg	0.14 mg	0.11 mg
	Pb	1,300 g	17,000 µg	13,000 µg
V, Fixed Costs / Insurance	Energy	5.3 GJ	71 kJ	54 kJ
	GHG	0.43 mt GGE	5.8 g GGE	4.4 g GGE
	SO_2	1.1 kg	14 mg	11 mg
	CO	4.8 kg	64 mg	49 mg
	NO_x	1.2 kg	16 mg	12 mg
	VOC	0.89 kg	12 mg	9.1 mg
	PM_{10}	0.23 kg	3.0 mg	2.3 mg
	Pb	-	-	-

Table 6 – Motorcycle (4 Cylinder, with Emissions Control) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	65 GJ	860 kJ	670 kJ
	GHG	5.4 mt GGE	73 g GGE	56 g GGE
	SO_2	17 kg	230 mg	170 mg
	CO	17 kg	230 mg	170 mg
	NO_X	26 kg	350 mg	270 mg
	VOC	34 kg	450 mg	350 mg
	PM_{10}	15 kg	200 mg	150 mg
	Pb	0.0032 kg	0.042 mg	0.032 mg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_X	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	380 MJ	5.0 kJ	3.8 kJ
	GHG	28 kg GGE	370 mg GGE	290 mg GGE
	SO_2	13 mg	0.17 µg	0.13 µg
	CO	100 mg	1.4 µg	1.0 µg
	NO_X	37 mg	0.50 µg	0.38 µg
	VOC	40 mg	0.53 µg	0.41 µg
	PM_{10}	7.7 mg	0.10 µg	0.079 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	4.8 GJ	64 kJ	49 kJ
	GHG	1.0 mt GGE	13 g GGE	10 g GGE
	SO_2	5.0 kg	67 mg	52 mg
	CO	0.49 kg	6.5 mg	5.0 mg
	NO_X	1.7 kg	22 mg	17 mg
	VOC	0.043 kg	0.57 mg	0.44 mg
	PM_{10}	0.055 kg	0.74 mg	0.57 mg
	Pb	0.000079 kg	0.0010 mg	0.00081 mg
I, Parking	Energy	24 GJ	320 kJ	250 kJ
	GHG	2.0 mt GGE	27 g GGE	21 g GGE
	SO_2	5.9 kg	79 mg	61 mg
	CO	8.6 kg	110 mg	88 mg
	NO_X	11 kg	140 mg	110 mg
	VOC	8.5 kg	110 mg	87 mg
	PM_{10}	4.4 kg	59 mg	45 mg
	Pb	0.0011 kg	0.015 mg	0.012 mg
F, Refining & Distribution	Energy	35 GJ	470 kJ	360 kJ
	GHG	3.2 mt GGE	43 g GGE	33 g GGE
	SO_2	6.0 kg	80 mg	62 mg
	CO	8.8 kg	120 mg	90 mg
	NO_X	5.1 kg	68 mg	53 mg
	VOC	3.8 kg	51 mg	39 mg
	PM_{10}	0.84 kg	11 mg	8.6 mg
	Pb	-	-	-

6.3 Motorcycle (2 Cylinder, no Emissions Control) Life-cycle Inventory

Table 7 – Motorcycle (2 Cylinder, no Emissions Control) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	120 GJ	1,700 kJ	1,300 kJ
	GHG	10 mt GGE	140 g GGE	110 g GGE
	SO_2	23 kg	300 mg	230 mg
	CO	130 kg	1,700 mg	1,300 mg
	NO_x	21 kg	280 mg	210 mg
	VOC	23 kg	310 mg	240 mg
	PM_{10}	8.6 kg	110 mg	88 mg
	Pb	0.046 kg	0.61 mg	0.47 mg
V, Operation (Running)	Energy	220 GJ	3,000 kJ	2,300 kJ
	GHG	15 mt GGE	200 g GGE	150 g GGE
	SO_2	0.84 kg	11 mg	8.6 mg
	CO	2,900 kg	38,000 mg	29,000 mg
	NO_x	4.5 kg	60 mg	46 mg
	VOC	490 kg	6,500 mg	5,000 mg
	PM_{10}	2.7 kg	36 mg	27 mg
	Pb	-	-	-
V, Operation (Start)	CO	490 kg	6,500 mg	5,000 mg
	NO_x	4.0 kg	53 mg	41 mg
	VOC	68 kg	910 mg	700 mg
V, Operation (Tire)	PM_{10}	0.30 kg	4.0 mg	3.1 mg
V, Operation (Brake)	PM_{10}	0.94 kg	13 mg	9.6 mg
V, Automotive Repair	GHG	380 g GGE	5,100 µg GGE	3,900 µg GGE
V, Automotive Repair	VOC	8.8 kg	120 mg	90 mg
V, Evaporative Losses	VOC	60 kg	800 mg	620 mg
V, Tire Production	Energy	28 GJ	370 kJ	290 kJ
	GHG	2.0 mt GGE	27 g GGE	21 g GGE
	SO_2	3.6 kg	48 mg	37 mg
	CO	28 kg	370 mg	290 mg
	NO_x	3.8 kg	50 mg	38 mg
	VOC	4.8 kg	64 mg	49 mg
	PM_{10}	-	-	-
	Pb	2.1 kg	28 mg	22 mg
V, Maintenance	Energy	22 GJ	290 kJ	220 kJ
	GHG	1.9 mt GGE	25 g GGE	19 g GGE
	SO_2	4.6 kg	62 mg	47 mg
	CO	23 kg	300 mg	230 mg
	NO_x	4.2 kg	56 mg	43 mg
	VOC	4.3 kg	57 mg	44 mg
	PM_{10}	0.012 kg	0.15 mg	0.12 mg
	Pb	1.4 kg	19 mg	14 mg
V, Fixed Costs / Insurance	Energy	2.5 GJ	34 kJ	26 kJ
	GHG	0.21 mt GGE	2.8 g GGE	2.1 g GGE
	SO_2	0.51 kg	6.8 mg	5.2 mg
	CO	2.3 kg	31 mg	24 mg
	NO_x	0.57 kg	7.7 mg	5.9 mg
	VOC	0.43 kg	5.7 mg	4.4 mg
	PM_{10}	0.11 kg	1.4 mg	1.1 mg
	Pb	-	-	-

Table 8 – Motorcycle (2 Cylinder, no Emissions Control) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	65 GJ	860 kJ	670 kJ
	GHG	5.4 mt GGE	73 g GGE	56 g GGE
	SO_2	-	-	-
	CO	17 kg	230 mg	170 mg
	NO_X	26 kg	350 mg	270 mg
	VOC	34 kg	450 mg	350 mg
	PM_{10}	15 kg	200 mg	150 mg
	Pb	0.0032 kg	0.042 mg	0.032 mg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_X	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	380 MJ	5.0 kJ	3.8 kJ
	GHG	28 kg GGE	370 mg GGE	290 mg GGE
	SO_2	13 mg	0.17 µg	0.13 µg
	CO	100 mg	1.4 µg	1.0 µg
	NO_X	37 mg	0.50 µg	0.38 µg
	VOC	40 mg	0.53 µg	0.41 µg
	PM_{10}	7.7 mg	0.10 µg	0.079 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	4.8 GJ	64 kJ	49 kJ
	GHG	1.0 mt GGE	13 g GGE	10 g GGE
	SO_2	5.0 kg	67 mg	52 mg
	CO	0.49 kg	6.5 mg	5.0 mg
	NO_X	1.7 kg	22 mg	17 mg
	VOC	0.043 kg	0.57 mg	0.44 mg
	PM_{10}	0.055 kg	0.74 mg	0.57 mg
	Pb	0.000079 kg	0.0010 mg	0.00081 mg
I, Parking	Energy	24 GJ	320 kJ	250 kJ
	GHG	2.0 mt GGE	27 g GGE	21 g GGE
	SO_2	5.9 kg	79 mg	61 mg
	CO	8.6 kg	110 mg	88 mg
	NO_X	11 kg	140 mg	110 mg
	VOC	8.5 kg	110 mg	87 mg
	PM_{10}	4.4 kg	59 mg	45 mg
	Pb	0.0011 kg	0.015 mg	0.012 mg
F, Refining & Distribution	Energy	32 GJ	430 kJ	330 kJ
	GHG	2.9 mt GGE	39 g GGE	30 g GGE
	SO_2	5.5 kg	73 mg	56 mg
	CO	8.0 kg	110 mg	82 mg
	NO_X	4.7 kg	62 mg	48 mg
	VOC	3.5 kg	46 mg	36 mg
	PM_{10}	0.76 kg	10 mg	7.8 mg
	Pb	-	-	-

6.4 Motorcycle (2 Cylinder, with Emissions Control) Life-cycle Inventory

Table 9 – Motorcycle (2 Cylinder, with Emissions Control) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	120 GJ	1,700 kJ	1,300 kJ
	GHG	10 mt GGE	140 g GGE	110 g GGE
	SO_2	23 kg	300 mg	230 mg
	CO	130 kg	1,700 mg	1,300 mg
	NO_x	21 kg	280 mg	210 mg
	VOC	23 kg	310 mg	240 mg
	PM_{10}	8.6 kg	110 mg	88 mg
	Pb	0.046 kg	0.61 mg	0.47 mg
V, Operation (Running)	Energy	220 GJ	3,000 kJ	2,300 kJ
	GHG	15 mt GGE	200 g GGE	150 g GGE
	SO_2	0.84 kg	11 mg	8.6 mg
	CO	340 kg	4,500 mg	3,500 mg
	NO_x	2.2 kg	30 mg	23 mg
	VOC	300 kg	4,000 mg	3,100 mg
	PM_{10}	2.7 kg	36 mg	27 mg
	Pb	-	-	-
V, Operation (Start)	CO	58 kg	770 mg	590 mg
	NO_x	2.0 kg	26 mg	20 mg
	VOC	42 kg	560 mg	430 mg
V, Operation (Tire)	PM_{10}	0.30 kg	4.0 mg	3.1 mg
V, Operation (Brake)	PM_{10}	0.94 kg	13 mg	9.6 mg
V, Automotive Repair	GHG	380 g GGE	5,100 µg GGE	3,900 µg GGE
V, Automotive Repair	VOC	8.8 kg	120 mg	90 mg
V, Evaporative Losses	VOC	37 kg	490 mg	380 mg
V, Tire Production	Energy	28 GJ	370 kJ	290 kJ
	GHG	2.0 mt GGE	27 g GGE	21 g GGE
	SO_2	3.6 kg	48 mg	37 mg
	CO	28 kg	370 mg	290 mg
	NO_x	3.8 kg	50 mg	38 mg
	VOC	4.8 kg	64 mg	49 mg
	PM_{10}	-	-	-
	Pb	2.1 kg	28 mg	22 mg
V, Maintenance	Energy	22 GJ	290 kJ	220 kJ
	GHG	1.9 mt GGE	25 g GGE	19 g GGE
	SO_2	4.6 kg	62 mg	47 mg
	CO	23 kg	300 mg	230 mg
	NO_x	4.2 kg	56 mg	43 mg
	VOC	4.3 kg	57 mg	44 mg
	PM_{10}	0.012 kg	0.15 mg	0.12 mg
	Pb	1.4 kg	19 mg	14 mg
V, Fixed Costs / Insurance	Energy	2.5 GJ	34 kJ	26 kJ
	GHG	0.21 mt GGE	2.8 g GGE	2.1 g GGE
	SO_2	0.51 kg	6.8 mg	5.2 mg
	CO	2.3 kg	31 mg	24 mg
	NO_x	0.57 kg	7.7 mg	5.9 mg
	VOC	0.43 kg	5.7 mg	4.4 mg
	PM_{10}	0.11 kg	1.4 mg	1.1 mg
	Pb	-	-	-

Table 10 – Motorcycle (2 Cylinder, with Emissions Control) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	65 GJ	860 kJ	670 kJ
	GHG	5.4 mt GGE	73 g GGE	56 g GGE
	SO_2	0.0032 kg	0.042 mg	0.032 mg
	CO	17 kg	230 mg	170 mg
	NO_X	26 kg	350 mg	270 mg
	VOC	34 kg	450 mg	350 mg
	PM_{10}	15 kg	200 mg	150 mg
	Pb	0.0032 kg	0.042 mg	0.032 mg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_X	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	380 MJ	5.0 kJ	3.8 kJ
	GHG	28 kg GGE	370 mg GGE	290 mg GGE
	SO_2	13 mg	0.17 µg	0.13 µg
	CO	100 mg	1.4 µg	1.0 µg
	NO_X	37 mg	0.50 µg	0.38 µg
	VOC	40 mg	0.53 µg	0.41 µg
	PM_{10}	7.7 mg	0.10 µg	0.079 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	4.8 GJ	64 kJ	49 kJ
	GHG	1.0 mt GGE	13 g GGE	10 g GGE
	SO_2	5.0 kg	67 mg	52 mg
	CO	0.49 kg	6.5 mg	5.0 mg
	NO_X	1.7 kg	22 mg	17 mg
	VOC	0.043 kg	0.57 mg	0.44 mg
	PM_{10}	0.055 kg	0.74 mg	0.57 mg
	Pb	0.000079 kg	0.0010 mg	0.00081 mg
I, Parking	Energy	24 GJ	320 kJ	250 kJ
	GHG	2.0 mt GGE	27 g GGE	21 g GGE
	SO_2	5.9 kg	79 mg	61 mg
	CO	8.6 kg	110 mg	88 mg
	NO_X	11 kg	140 mg	110 mg
	VOC	8.5 kg	110 mg	87 mg
	PM_{10}	4.4 kg	59 mg	45 mg
	Pb	0.0011 kg	0.015 mg	0.012 mg
F, Refining & Distribution	Energy	32 GJ	430 kJ	330 kJ
	GHG	2.9 mt GGE	39 g GGE	30 g GGE
	SO_2	5.5 kg	73 mg	56 mg
	CO	8.0 kg	110 mg	82 mg
	NO_X	4.7 kg	62 mg	48 mg
	VOC	3.5 kg	46 mg	36 mg
	PM_{10}	0.76 kg	10 mg	7.8 mg
	Pb	-	-	-

6.5 Motorcycle (Sports Bike) Life-cycle Inventory

Table 11 – Motorcycle (Sports Bike) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	82 GJ	1,400 kJ	1,400 kJ
	GHG	7.0 mt GGE	120 g GGE	120 g GGE
	SO_2	15 kg	250 mg	250 mg
	CO	84 kg	1,400 mg	1,400 mg
	NO_x	14 kg	230 mg	230 mg
	VOC	15 kg	260 mg	260 mg
	PM_{10}	5.7 kg	95 mg	95 mg
	Pb	0.031 kg	0.51 mg	0.51 mg
V, Operation (Running)	Energy	240 GJ	4,000 kJ	4,000 kJ
	GHG	16 mt GGE	270 g GGE	270 g GGE
	SO_2	0.91 kg	15 mg	15 mg
	CO	1,800 kg	30,000 mg	30,000 mg
	NO_x	36 kg	600 mg	600 mg
	VOC	260 kg	4,400 mg	4,400 mg
	PM_{10}	2.9 kg	48 mg	48 mg
	Pb	-	-	-
V, Operation (Start)	CO	310 kg	5,100 mg	5,100 mg
	NO_x	32 kg	530 mg	530 mg
	VOC	37 kg	610 mg	610 mg
V, Operation (Tire)	PM_{10}	0.24 kg	4.0 mg	4.0 mg
V, Operation (Brake)	PM_{10}	0.75 kg	13 mg	13 mg
V, Automotive Repair	GHG	300 g GGE	5,100 µg GGE	5,100 µg GGE
V, Automotive Repair	VOC	7.0 kg	120 mg	120 mg
V, Evaporative Losses	VOC	32 kg	540 mg	540 mg
V, Tire Production	Energy	37 GJ	620 kJ	620 kJ
	GHG	2.7 mt GGE	45 g GGE	45 g GGE
	SO_2	4.8 kg	81 mg	81 mg
	CO	37 kg	620 mg	620 mg
	NO_x	5.0 kg	83 mg	83 mg
	VOC	6.4 kg	110 mg	110 mg
	PM_{10}	-	-	-
	Pb	2.8 kg	47 mg	47 mg
V, Maintenance	Energy	14 GJ	240 kJ	240 kJ
	GHG	1.2 mt GGE	21 g GGE	21 g GGE
	SO_2	3.1 kg	51 mg	51 mg
	CO	15 kg	250 mg	250 mg
	NO_x	2.8 kg	46 mg	46 mg
	VOC	2.8 kg	47 mg	47 mg
	PM_{10}	0.0076 kg	0.13 mg	0.13 mg
	Pb	0.92 kg	15 mg	15 mg
V, Fixed Costs / Insurance	Energy	17 GJ	280 kJ	280 kJ
	GHG	1.4 mt GGE	23 g GGE	23 g GGE
	SO_2	3.4 kg	57 mg	57 mg
	CO	15 kg	260 mg	260 mg
	NO_x	3.8 kg	64 mg	64 mg
	VOC	2.8 kg	47 mg	47 mg
	PM_{10}	0.72 kg	12 mg	12 mg
	Pb	-	-	-

Table 12 – Motorcycle (Sports Bike) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	52 GJ	860 kJ	860 kJ
	GHG	4.4 mt GGE	73 g GGE	73 g GGE
	SO_2	-	-	-
	CO	14 kg	230 mg	230 mg
	NO_X	21 kg	350 mg	350 mg
	VOC	27 kg	450 mg	450 mg
	PM_{10}	12 kg	200 mg	200 mg
	Pb	0.0025 kg	0.042 mg	0.042 mg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_X	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	300 MJ	5.0 kJ	5.0 kJ
	GHG	22 kg GGE	370 mg GGE	370 mg GGE
	SO_2	10 mg	0.17 µg	0.17 µg
	CO	82 mg	1.4 µg	1.4 µg
	NO_X	30 mg	0.50 µg	0.50 µg
	VOC	32 mg	0.53 µg	0.53 µg
	PM_{10}	6.2 mg	0.10 µg	0.10 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	3.8 GJ	64 kJ	64 kJ
	GHG	0.81 mt GGE	13 g GGE	13 g GGE
	SO_2	4.0 kg	67 mg	67 mg
	CO	0.39 kg	6.5 mg	6.5 mg
	NO_X	1.3 kg	22 mg	22 mg
	VOC	0.034 kg	0.57 mg	0.57 mg
	PM_{10}	0.044 kg	0.74 mg	0.74 mg
	Pb	0.000063 kg	0.0010 mg	0.0010 mg
I, Parking	Energy	19 GJ	320 kJ	320 kJ
	GHG	1.6 mt GGE	27 g GGE	27 g GGE
	SO_2	4.8 kg	79 mg	79 mg
	CO	6.9 kg	110 mg	110 mg
	NO_X	8.4 kg	140 mg	140 mg
	VOC	6.8 kg	110 mg	110 mg
	PM_{10}	3.5 kg	59 mg	59 mg
	Pb	0.00092 kg	0.015 mg	0.015 mg
F, Refining & Distribution	Energy	35 GJ	580 kJ	580 kJ
	GHG	3.1 mt GGE	52 g GGE	52 g GGE
	SO_2	5.9 kg	98 mg	98 mg
	CO	8.7 kg	140 mg	140 mg
	NO_X	5.0 kg	84 mg	84 mg
	VOC	3.8 kg	63 mg	63 mg
	PM_{10}	0.82 kg	14 mg	14 mg
	Pb	-	-	-

6.6 Light Duty Diesel Sedan Life-cycle Inventory

Table 13 – Light Duty Diesel Sedan Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	120 GJ	630 kJ	400 kJ
	GHG	9.8 mt GGE	52 g GGE	33 g GGE
	SO_2	23 kg	120 mg	77 mg
	CO	120 kg	640 mg	410 mg
	NO_x	23 kg	120 mg	76 mg
	VOC	24 kg	130 mg	80 mg
	PM_{10}	6.5 kg	35 mg	22 mg
	Pb	0.031 kg	0.17 mg	0.10 mg
V, Operation (Running)	Energy	870 GJ	4,700 kJ	2,900 kJ
	GHG	65 mt GGE	340 g GGE	220 g GGE
	SO_2	0.60 kg	3.2 mg	2.0 mg
	CO	150 kg	810 mg	510 mg
	NO_x	240 kg	1,300 mg	800 mg
	VOC	62 kg	330 mg	210 mg
	PM_{10}	30 kg	160 mg	100 mg
	Pb	-	-	-
V, Operation (Start)	CO	140 kg	760 mg	480 mg
	NO_x	14 kg	72 mg	46 mg
	VOC	47 kg	250 mg	160 mg
V, Operation (Tire)	PM_{10}	1.5 kg	8.0 mg	5.1 mg
V, Operation (Brake)	PM_{10}	2.3 kg	13 mg	7.9 mg
V, Automotive Repair	GHG	950 g GGE	5,100 µg GGE	3,200 µg GGE
V, Automotive Repair	VOC	22 kg	120 mg	74 mg
V, Evaporative Losses	VOC	-	-	-
V, Tire Production	Energy	19 GJ	99 kJ	63 kJ
	GHG	1.3 mt GGE	7.2 g GGE	4.5 g GGE
	SO_2	2.4 kg	13 mg	8.2 mg
	CO	19 kg	100 mg	63 mg
	NO_x	2.5 kg	13 mg	8.4 mg
	VOC	3.2 kg	17 mg	11 mg
	PM_{10}	-	-	-
	Pb	1.4 kg	7.5 mg	4.7 mg
V, Maintenance	Energy	40 GJ	210 kJ	140 kJ
	GHG	3.3 mt GGE	17 g GGE	11 g GGE
	SO_2	8.4 kg	45 mg	28 mg
	CO	33 kg	180 mg	110 mg
	NO_x	7.7 kg	41 mg	26 mg
	VOC	9.7 kg	52 mg	33 mg
	PM_{10}	-	-	-
	Pb	1.6 kg	8.8 mg	5.6 mg
V, Fixed Costs / Insurance	Energy	13 GJ	69 kJ	44 kJ
	GHG	1.1 mt GGE	5.6 g GGE	3.6 g GGE
	SO_2	2.6 kg	14 mg	8.7 mg
	CO	12 kg	62 mg	39 mg
	NO_x	2.9 kg	16 mg	9.8 mg
	VOC	2.2 kg	12 mg	7.3 mg
	PM_{10}	0.55 kg	2.9 mg	1.9 mg
	Pb	-	-	-

Table 14 – Light Duty Diesel Sedan Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	160 GJ	860 kJ	550 kJ
	GHG	14 mt GGE	73 g GGE	46 g GGE
	SO_2	26 kg	140 mg	89 mg
	CO	42 kg	230 mg	140 mg
	NO_X	65 kg	350 mg	220 mg
	VOC	85 kg	450 mg	290 mg
	PM_{10}	37 kg	200 mg	120 mg
	Pb	0.0079 kg	0.042 mg	0.027 mg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_X	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	940 MJ	5.0 kJ	3.2 kJ
	GHG	70 kg GGE	370 mg GGE	240 mg GGE
	SO_2	140 mg	0.74 µg	0.47 µg
	CO	250 mg	1.4 µg	0.86 µg
	NO_X	93 mg	0.50 µg	0.31 µg
	VOC	100 mg	0.53 µg	0.34 µg
	PM_{10}	19 mg	0.10 µg	0.065 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	12 GJ	64 kJ	40 kJ
	GHG	2.5 mt GGE	13 g GGE	8.5 g GGE
	SO_2	13 kg	67 mg	43 mg
	CO	1.2 kg	6.5 mg	4.1 mg
	NO_X	4.2 kg	22 mg	14 mg
	VOC	0.11 kg	0.57 mg	0.36 mg
	PM_{10}	0.14 kg	0.74 mg	0.47 mg
	Pb	0.00020 kg	0.0010 mg	0.00066 mg
I, Parking	Energy	15 GJ	79 kJ	50 kJ
	GHG	1.2 mt GGE	6.6 g GGE	4.2 g GGE
	SO_2	3.6 kg	19 mg	12 mg
	CO	5.2 kg	28 mg	18 mg
	NO_X	6.4 kg	34 mg	22 mg
	VOC	5.2 kg	27 mg	17 mg
	PM_{10}	2.7 kg	14 mg	9.0 mg
	Pb	0.00070 kg	0.0037 mg	0.0024 mg
F, Refining & Distribution	Energy	110 GJ	610 kJ	390 kJ
	GHG	10 mt GGE	56 g GGE	35 g GGE
	SO_2	20 kg	100 mg	66 mg
	CO	29 kg	150 mg	97 mg
	NO_X	17 kg	91 mg	57 mg
	VOC	12 kg	66 mg	42 mg
	PM_{10}	2.8 kg	15 mg	9.4 mg
	Pb	-	-	-

6.7 Light Duty Diesel Truck Life-cycle Inventory

Table 15 – Light Duty Diesel Truck Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	110 GJ	670 kJ	460 kJ
	GHG	9.5 mt GGE	55 g GGE	38 g GGE
	SO_2	22 kg	130 mg	88 mg
	CO	120 kg	680 mg	470 mg
	NO_x	22 kg	130 mg	88 mg
	VOC	23 kg	130 mg	92 mg
	PM_{10}	6.4 kg	37 mg	25 mg
	Pb	0.030 kg	0.18 mg	0.12 mg
V, Operation (Running)	Energy	1,300 GJ	7,700 kJ	5,300 kJ
	GHG	98 mt GGE	570 g GGE	390 g GGE
	SO_2	0.92 kg	5.4 mg	3.7 mg
	CO	120 kg	710 mg	490 mg
	NO_x	230 kg	1,300 mg	910 mg
	VOC	81 kg	470 mg	320 mg
	PM_{10}	25 kg	150 mg	100 mg
	Pb	-	-	-
V, Operation (Start)	CO	120 kg	680 mg	460 mg
	NO_x	12 kg	70 mg	48 mg
	VOC	58 kg	340 mg	230 mg
V, Operation (Tire)	PM_{10}	1.4 kg	8.0 mg	5.5 mg
V, Operation (Brake)	PM_{10}	2.2 kg	13 mg	8.6 mg
V, Automotive Repair	GHG	870 g GGE	5,100 µg GGE	3,500 µg GGE
V, Automotive Repair	VOC	20 kg	120 mg	80 mg
V, Evaporative Losses	VOC	-	-	-
V, Tire Production	Energy	17 GJ	99 kJ	68 kJ
	GHG	1.2 mt GGE	7.2 g GGE	4.9 g GGE
	SO_2	2.2 kg	13 mg	8.8 mg
	CO	17 kg	100 mg	68 mg
	NO_x	2.3 kg	13 mg	9.1 mg
	VOC	2.9 kg	17 mg	12 mg
	PM_{10}	-	-	-
	Pb	1.3 kg	7.5 mg	5.1 mg
V, Maintenance	Energy	41 GJ	240 kJ	160 kJ
	GHG	3.3 mt GGE	19 g GGE	13 g GGE
	SO_2	8.6 kg	50 mg	34 mg
	CO	34 kg	200 mg	140 mg
	NO_x	7.9 kg	46 mg	31 mg
	VOC	10.0 kg	58 mg	40 mg
	PM_{10}	-	-	-
	Pb	1.7 kg	9.8 mg	6.7 mg
V, Fixed Costs / Insurance	Energy	12 GJ	71 kJ	48 kJ
	GHG	0.99 mt GGE	5.8 g GGE	4.0 g GGE
	SO_2	2.4 kg	14 mg	9.7 mg
	CO	11 kg	64 mg	44 mg
	NO_x	2.7 kg	16 mg	11 mg
	VOC	2.0 kg	12 mg	8.1 mg
	PM_{10}	0.52 kg	3.0 mg	2.1 mg
	Pb	-	-	-

Table 16 – Light Duty Diesel Truck Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	150 GJ	860 kJ	590 kJ
	GHG	13 mt GGE	73 g GGE	50 g GGE
	SO_2	24 kg	140 mg	96 mg
	CO	39 kg	230 mg	150 mg
	NO_x	60 kg	350 mg	240 mg
	VOC	78 kg	450 mg	310 mg
	PM_{10}	34 kg	200 mg	130 mg
	Pb	0.0073 kg	0.042 mg	0.029 mg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	860 MJ	5.0 kJ	3.4 kJ
	GHG	64 kg GGE	370 mg GGE	260 mg GGE
	SO_2	130 mg	0.75 µg	0.51 µg
	CO	230 mg	1.4 µg	0.93 µg
	NO_x	86 mg	0.50 µg	0.34 µg
	VOC	92 mg	0.53 µg	0.36 µg
	PM_{10}	18 mg	0.10 µg	0.071 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	11 GJ	64 kJ	44 kJ
	GHG	2.3 mt GGE	13 g GGE	9.2 g GGE
	SO_2	12 kg	67 mg	46 mg
	CO	1.1 kg	6.5 mg	4.4 mg
	NO_x	3.8 kg	22 mg	15 mg
	VOC	0.099 kg	0.58 mg	0.39 mg
	PM_{10}	0.13 kg	0.74 mg	0.51 mg
	Pb	0.00018 kg	0.0011 mg	0.00072 mg
I, Parking	Energy	15 GJ	87 kJ	59 kJ
	GHG	1.3 mt GGE	7.3 g GGE	5.0 g GGE
	SO_2	3.7 kg	21 mg	15 mg
	CO	5.3 kg	31 mg	21 mg
	NO_x	6.5 kg	38 mg	26 mg
	VOC	5.2 kg	30 mg	21 mg
	PM_{10}	2.7 kg	16 mg	11 mg
	Pb	0.00071 kg	0.0041 mg	0.0028 mg
F, Refining & Distribution	Energy	180 GJ	1,000 kJ	700 kJ
	GHG	16 mt GGE	93 g GGE	63 g GGE
	SO_2	30 kg	170 mg	120 mg
	CO	44 kg	260 mg	170 mg
	NO_x	26 kg	150 mg	100 mg
	VOC	19 kg	110 mg	76 mg
	PM_{10}	4.2 kg	25 mg	17 mg
	Pb	-	-	-

6.8 School Bus Life-cycle Inventory

Table 17 – School Bus Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	490 GJ	2,900 kJ	47 kJ
	GHG	39 mt GGE	230 g GGE	3.7 g GGE
	SO_2	95 kg	580 mg	9.1 mg
	CO	440 kg	2,700 mg	43 mg
	NO_x	86 kg	520 mg	8.3 mg
	VOC	110 kg	680 mg	11 mg
	PM_{10}	25 kg	150 mg	2.4 mg
	Pb	0.12 kg	0.70 mg	0.011 mg
V, Operation (Running)	Energy	3,700 GJ	22,000 kJ	350 kJ
	GHG	270 mt GGE	1,600 g GGE	26 g GGE
	SO_2	2.5 kg	15 mg	0.24 mg
	CO	440 kg	2,700 mg	42 mg
	NO_x	2,000 kg	12,000 mg	200 mg
	VOC	120 kg	740 mg	12 mg
	PM_{10}	130 kg	810 mg	13 mg
	Pb	-	-	-
V, Operation (Start)	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
V, Operation (Tire)	PM_{10}	2.0 kg	12 mg	0.19 mg
V, Operation (Brake)	PM_{10}	2.1 kg	13 mg	0.20 mg
V, Automotive Repair	GHG	840 g GGE	5,100 µg GGE	81 µg GGE
V, Automotive Repair	VOC	19 kg	120 mg	1.9 mg
V, Evaporative Losses	VOC	-	-	-
V, Tire Production	Energy	18 GJ	110 kJ	1.7 kJ
	GHG	1.3 mt GGE	7.7 g GGE	0.12 g GGE
	SO_2	2.3 kg	14 mg	0.22 mg
	CO	18 kg	110 mg	1.7 mg
	NO_x	2.4 kg	14 mg	0.23 mg
	VOC	3.0 kg	18 mg	0.29 mg
	PM_{10}	-	-	-
	Pb	1.3 kg	8.1 mg	0.13 mg
V, Maintenance	Energy	270 GJ	1,700 kJ	26 kJ
	GHG	22 mt GGE	130 g GGE	2.1 g GGE
	SO_2	57 kg	350 mg	5.5 mg
	CO	230 kg	1,400 mg	22 mg
	NO_x	52 kg	320 mg	5.0 mg
	VOC	66 kg	400 mg	6.4 mg
	PM_{10}	-	-	-
	Pb	11 kg	68 mg	1.1 mg
V, Fixed Costs / Insurance	Energy	110 GJ	650 kJ	10 kJ
	GHG	8.8 mt GGE	53 g GGE	0.84 g GGE
	SO_2	22 kg	130 mg	2.1 mg
	CO	97 kg	590 mg	9.4 mg
	NO_x	24 kg	150 mg	2.3 mg
	VOC	18 kg	110 mg	1.7 mg
	PM_{10}	4.6 kg	28 mg	0.44 mg
	Pb	-	-	-

Table 18 – School Bus Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	150 GJ	890 kJ	14 kJ
	GHG	12 mt GGE	75 g GGE	1.2 g GGE
	SO_2	24 kg	150 mg	2.3 mg
	CO	38 kg	230 mg	3.7 mg
	NO_x	59 kg	360 mg	5.7 mg
	VOC	77 kg	470 mg	7.4 mg
	PM_{10}	33 kg	200 mg	3.2 mg
	Pb	0.0072 kg	0.044 mg	0.00069 mg
I, Roadway Maintenance	Energy	7,200 GJ	44,000 kJ	690 kJ
	GHG	610 mt GGE	3,700 g GGE	58 g GGE
	SO_2	1,200 kg	7,100 mg	110 mg
	CO	1,900 kg	11,000 mg	180 mg
	NO_x	2,800 kg	17,000 mg	270 mg
	VOC	3,900 kg	24,000 mg	380 mg
	PM_{10}	1,600 kg	10,000 mg	160 mg
	Pb	0.36 kg	2.2 mg	0.034 mg
I, Herbicides / Salting	Energy	800 MJ	4.9 kJ	0.077 kJ
	GHG	60 kg GGE	360 mg GGE	5.7 mg GGE
	SO_2	46 mg	0.28 µg	0.0044 µg
	CO	220 mg	1.3 µg	0.021 µg
	NO_x	80 mg	0.48 µg	0.0077 µg
	VOC	85 mg	0.52 µg	0.0082 µg
	PM_{10}	16 mg	0.100 µg	0.0016 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	10 GJ	62 kJ	0.99 kJ
	GHG	2.2 mt GGE	13 g GGE	0.21 g GGE
	SO_2	11 kg	65 mg	1.0 mg
	CO	1.0 kg	6.3 mg	0.100 mg
	NO_x	3.6 kg	22 mg	0.34 mg
	VOC	0.092 kg	0.56 mg	0.0089 mg
	PM_{10}	0.12 kg	0.72 mg	0.011 mg
	Pb	0.00017 kg	0.0010 mg	0.000016 mg
I, Parking	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
F, Refining & Distribution	Energy	480 GJ	2,900 kJ	46 kJ
	GHG	44 mt GGE	270 g GGE	4.2 g GGE
	SO_2	82 kg	500 mg	7.9 mg
	CO	120 kg	730 mg	12 mg
	NO_x	71 kg	430 mg	6.9 mg
	VOC	52 kg	320 mg	5.0 mg
	PM_{10}	12 kg	71 mg	1.1 mg
	Pb	-	-	-

6.9 Electric Bus Life-cycle Inventory

Table 19 – Electric Bus Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	1,900 GJ	12,000 kJ	190 kJ
	GHG	150 mt GGE	940 g GGE	15 g GGE
	SO_2	380 kg	2,300 mg	37 mg
	CO	1,800 kg	11,000 mg	170 mg
	NO_x	350 kg	2,100 mg	33 mg
	VOC	450 kg	2,700 mg	43 mg
	PM_{10}	99 kg	600 mg	9.6 mg
	Pb	0.46 kg	2.8 mg	0.044 mg
V, Operation (Running)	Energy	5,600 GJ	34,000 kJ	540 kJ
	GHG	310 mt GGE	1,900 g GGE	30 g GGE
	SO_2	1,800 kg	11,000 mg	170 mg
	CO	180 kg	1,100 mg	17 mg
	NO_x	100 kg	620 mg	9.8 mg
	VOC	47 kg	280 mg	4.5 mg
	PM_{10}	19 kg	120 mg	1.8 mg
	Pb	0.0011 kg	0.0069 mg	0.00011 mg
V, Operation (Start)	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
V, Operation (Tire)	PM_{10}	6.0 kg	36 mg	0.58 mg
V, Operation (Brake)	PM_{10}	6.3 kg	38 mg	0.60 mg
V, Automotive Repair	GHG	83 g GGE	500 µg GGE	8.0 µg GGE
V, Automotive Repair	VOC	1.9 kg	12 mg	0.18 mg
V, Evaporative Losses	VOC	-	-	-
V, Tire Production	Energy	200 GJ	1,200 kJ	19 kJ
	GHG	11 mt GGE	66 g GGE	1.1 g GGE
	SO_2	61 kg	370 mg	5.9 mg
	CO	6.2 kg	37 mg	0.59 mg
	NO_x	3.6 kg	22 mg	0.34 mg
	VOC	1.6 kg	9.9 mg	0.16 mg
	PM_{10}	0.67 kg	4.0 mg	0.064 mg
	Pb	0.000040 kg	0.00024 mg	0.0000038 mg
V, Maintenance	Energy	18 GJ	110 kJ	1.7 kJ
	GHG	1.3 mt GGE	7.7 g GGE	0.12 g GGE
	SO_2	2.3 kg	14 mg	0.22 mg
	CO	18 kg	110 mg	1.7 mg
	NO_x	2.4 kg	14 mg	0.23 mg
	VOC	3.0 kg	18 mg	0.29 mg
	PM_{10}	-	-	-
	Pb	1.3 kg	8.1 mg	0.13 mg
V, Fixed Costs / Insurance	Energy	270 GJ	1,700 kJ	26 kJ
	GHG	22 mt GGE	130 g GGE	2.1 g GGE
	SO_2	57 kg	350 mg	5.5 mg
	CO	230 kg	1,400 mg	22 mg
	NO_x	52 kg	320 mg	5.0 mg
	VOC	66 kg	400 mg	6.4 mg
	PM_{10}	-	-	-
	Pb	11 kg	68 mg	1.1 mg

Table 20 – Electric Bus Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	260 GJ	1,600 kJ	25 kJ
	GHG	22 mt GGE	130 g GGE	2.1 g GGE
	SO_2	42 kg	250 mg	4.0 mg
	CO	67 kg	410 mg	6.4 mg
	NO_X	100 kg	630 mg	9.9 mg
	VOC	130 kg	820 mg	13 mg
	PM_{10}	130 kg	820 mg	13 mg
	Pb	0.013 kg	0.076 mg	0.0012 mg
I, Roadway Maintenance	Energy	300 GJ	1,800 kJ	29 kJ
	GHG	26 mt GGE	150 g GGE	2.5 g GGE
	SO_2	49 kg	300 mg	4.7 mg
	CO	79 kg	480 mg	7.6 mg
	NO_X	120 kg	710 mg	11 mg
	VOC	160 kg	1,000 mg	16 mg
	PM_{10}	69 kg	420 mg	6.6 mg
	Pb	0.015 kg	0.091 mg	0.0014 mg
I, Herbicides / Salting	Energy	590 MJ	3.6 kJ	0.057 kJ
	GHG	44 kg GGE	270 mg GGE	4.2 mg GGE
	SO_2	88 mg	0.53 µg	0.0084 µg
	CO	160 mg	0.97 µg	0.015 µg
	NO_X	59 mg	0.35 µg	0.0056 µg
	VOC	63 mg	0.38 µg	0.0060 µg
	PM_{10}	12 mg	0.073 µg	0.0012 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	7.5 GJ	46 kJ	0.72 kJ
	GHG	1.6 mt GGE	9.6 g GGE	0.15 g GGE
	SO_2	7.9 kg	48 mg	0.76 mg
	CO	0.76 kg	4.6 mg	0.073 mg
	NO_X	2.6 kg	16 mg	0.25 mg
	VOC	0.068 kg	0.41 mg	0.0065 mg
	PM_{10}	0.087 kg	0.53 mg	0.0084 mg
	Pb	0.00012 kg	0.00075 mg	0.000012 mg
I, Parking	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_X	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
F, Refining & Distribution	Energy	2,500 GJ	15,000 kJ	240 kJ
	GHG	110 mt GGE	680 g GGE	11 g GGE
	SO_2	2,000 kg	12,000 mg	190 mg
	CO	150 kg	900 mg	14 mg
	NO_X	170 kg	1,100 mg	17 mg
	VOC	17 kg	100 mg	1.6 mg
	PM_{10}	8.2 kg	50 mg	0.79 mg
	Pb	0.00088 kg	0.0053 mg	0.000084 mg

6.10 New York City Metro Life-cycle Inventory

Table 21 – New York City Metro Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	22 TJ	11 MJ	0.050 MJ
	GHG	1,300 mt GGE	660 g GGE	3.0 g GGE
	SO2	5,000 kg	2,500 mg	11 mg
	CO	1,500 kg	750 mg	3.5 mg
	NOX	2,700 kg	1,400 mg	6.3 mg
	VOC	690 kg	340 mg	1.6 mg
	Pb	5.7 kg	2.8 mg	13 µg
	PM10	1,400 kg	690 mg	3,200 µg
V, Operation (Active)	Energy	200 TJ	99 MJ	0.46 MJ
	GHG	20,000 mt GGE	9,900 g GGE	46 g GGE
	SO2	100,000 kg	49,000 mg	230 mg
	CO	28,000 kg	14,000 mg	64 mg
	NOX	27,000 kg	14,000 mg	63 mg
	VOC	1,000 kg	500 mg	2.3 mg
	Pb	1.2 kg	0.58 mg	2.7 µg
	PM10	1,200 kg	610 mg	2,800 µg
V, Operation (Idling)	Energy	100 TJ	51 MJ	0.23 MJ
	GHG	10,000 mt GGE	5,000 g GGE	23 g GGE
	SO2	51,000 kg	25,000 mg	120 mg
	CO	14,000 kg	7,100 mg	33 mg
	NOX	14,000 kg	6,900 mg	32 mg
	VOC	510 kg	250 mg	1.2 mg
	Pb	0.60 kg	0.30 mg	1.4 µg
	PM10	620 kg	310 mg	1,400 µg
V, Operation (HVAC)	Energy	30 TJ	15 MJ	0.069 MJ
	GHG	3,000 mt GGE	1,500 g GGE	6.9 g GGE
	SO2	15,000 kg	7,400 mg	34 mg
	CO	4,200 kg	2,100 mg	9.6 mg
	NOX	4,100 kg	2,000 mg	9.4 mg
	VOC	150 kg	75 mg	0.34 mg
	Pb	0.18 kg	0.088 mg	0.40 µg
	PM10	180 kg	92 mg	420 µg
V, Maintenance	Energy	18 TJ	8.8 MJ	0.041 MJ
	GHG	810 mt GGE	400 g GGE	1.9 g GGE
	SO2	2,200 kg	1,100 mg	5.1 mg
	CO	2,000 kg	1,000 mg	4.6 mg
	NOX	1,900 kg	940 mg	4.3 mg
	VOC	2,900 kg	1,500 mg	6.7 mg
	Pb	7.9 kg	3.9 mg	18 µg
	PM10	560 kg	280 mg	1,300 µg
V, Maintenance (Cleaning)	Energy	0.32 TJ	0.16 MJ	0.00073 MJ
	GHG	13 mt GGE	6.6 g GGE	0.030 g GGE
	SO2	66 kg	33 mg	0.15 mg
	CO	19 kg	9.2 mg	0.043 mg
	NOX	18 kg	9.0 mg	0.041 mg
	VOC	0.66 kg	0.33 mg	0.0015 mg
	Pb	0.00078 kg	0.00039 mg	0.0018 µg
	PM10	0.81 kg	0.40 mg	1.9 µg
V, Maintenance (Flooring)	Energy	0.53 TJ	0.26 MJ	0.0012 MJ
	GHG	40 mt GGE	20 g GGE	0.092 g GGE
	SO2	82 kg	41 mg	0.19 mg
	CO	290 kg	150 mg	0.67 mg
	NOX	74 kg	37 mg	0.17 mg
	VOC	67 kg	33 mg	0.15 mg
	Pb	-	-	-
	PM10	13 kg	6.6 mg	31 µg
V, Insurance (Employees)	Energy	31 TJ	16 MJ	0.072 MJ
	GHG	2,600 mt GGE	1,300 g GGE	5.9 g GGE
	SO2	6,300 kg	3,100 mg	14 mg
	CO	28,000 kg	14,000 mg	65 mg
	NOX	7,100 kg	3,500 mg	16 mg
	VOC	5,200 kg	2,600 mg	12 mg
	Pb	-	-	-
	PM10	1,300 kg	660 mg	3,100 µg
V, Insurance (Vehicles)	Energy	1.2 TJ	0.59 MJ	0.0027 MJ
	GHG	97 mt GGE	48 g GGE	0.22 g GGE
	SO2	240 kg	120 mg	0.55 mg
	CO	1,100 kg	530 mg	2.5 mg
	NOX	270 kg	130 mg	0.61 mg
	VOC	200 kg	99 mg	0.46 mg
	Pb	-	-	-
	PM10	51 kg	25 mg	120 µg

Table 22 – New York City Metro Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	110 TJ	56 MJ	0.26 MJ
	GHG	11,000 mt GGE	5,600 g GGE	26 g GGE
	SO2	34,000 kg	17,000 mg	78 mg
	CO	92,000 kg	46,000 mg	210 mg
	NOX	47,000 kg	23,000 mg	110 mg
	VOC	30,000 kg	15,000 mg	68 mg
	Pb	5.2 kg	2.6 mg	12 µg
	PM10	6,000 kg	3,000 mg	14,000 µg
I, Station Lighting	Energy	73 TJ	36 MJ	0.17 MJ
	GHG	7,300 mt GGE	3,600 g GGE	17 g GGE
	SO2	36,000 kg	18,000 mg	83 mg
	CO	10,000 kg	5,100 mg	23 mg
	NOX	10,000 kg	4,900 mg	23 mg
	VOC	360 kg	180 mg	0.84 mg
	Pb	0.43 kg	0.21 mg	0.98 µg
	PM10	450 kg	220 mg	1,000 µg
I, Station Escalators	Energy	3.6 TJ	1.8 MJ	0.0083 MJ
	GHG	360 mt GGE	180 g GGE	0.82 g GGE
	SO2	1,800 kg	890 mg	4.1 mg
	CO	500 kg	250 mg	1.2 mg
	NOX	490 kg	240 mg	1.1 mg
	VOC	18 kg	8.9 mg	0.041 mg
	Pb	0.021 kg	0.011 mg	0.048 µg
	PM10	22 kg	11 mg	51 µg
I, Station Train Control	Energy	15 TJ	7.3 MJ	0.034 MJ
	GHG	1,500 mt GGE	730 g GGE	3.3 g GGE
	SO2	7,300 kg	3,600 mg	17 mg
	CO	2,100 kg	1,000 mg	4.7 mg
	NOX	2,000 kg	990 mg	4.6 mg
	VOC	73 kg	36 mg	0.17 mg
	Pb	0.086 kg	0.043 mg	0.20 µg
	PM10	90 kg	45 mg	210 µg
I, Station Parking Lighting	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
I, Station Miscellaneous	Energy	5.4 TJ	2.7 MJ	0.012 MJ
	GHG	530 mt GGE	260 g GGE	1.2 g GGE
	SO2	2,700 kg	1,300 mg	6.1 mg
	CO	750 kg	370 mg	1.7 mg
	NOX	730 kg	360 mg	1.7 mg
	VOC	27 kg	13 mg	0.061 mg
	Pb	0.031 kg	0.016 mg	0.072 µg
	PM10	33 kg	16 mg	75 µg
I, Station Maintenance	Energy	11 TJ	5.6 MJ	0.026 MJ
	GHG	1,100 mt GGE	560 g GGE	2.6 g GGE
	SO2	3,400 kg	1,700 mg	7.8 mg
	CO	9,200 kg	4,600 mg	21 mg
	NOX	4,700 kg	2,300 mg	11 mg
	VOC	3,000 kg	1,500 mg	6.8 mg
	Pb	0.52 kg	0.26 mg	1.2 µg
	PM10	600 kg	300 mg	1,400 µg
I, Station Cleaning	Energy	0.32 TJ	0.16 MJ	0.00073 MJ
	GHG	13 mt GGE	6.6 g GGE	0.030 g GGE
	SO2	66 kg	33 mg	0.15 mg
	CO	19 kg	9.2 mg	0.043 mg
	NOX	18 kg	9.0 mg	0.041 mg
	VOC	0.66 kg	0.33 mg	0.0015 mg
	Pb	0.00078 kg	0.00039 mg	0.0018 µg
	PM10	0.81 kg	0.40 mg	1.9 µg
I, Station Parking	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-

(Table 22 continued on the following page…)

Table 22 – New York City Metro Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	3.2 TJ	1.6 MJ	0.0074 MJ
	GHG	300 mt GGE	150 g GGE	0.69 g GGE
	SO2	630 kg	310 mg	1.4 mg
	CO	2,700 kg	1,300 mg	6.2 mg
	NOX	660 kg	330 mg	1.5 mg
	VOC	430 kg	210 mg	0.98 mg
	Pb	1.1 kg	0.57 mg	2.6 µg
	PM10	240 kg	120 mg	550 µg
I, Track Maintenance	Energy	4.0 TJ	2.0 MJ	0.0091 MJ
	GHG	160 mt GGE	82 g GGE	0.38 g GGE
	SO2	150 kg	77 mg	0.35 mg
	CO	80 kg	40 mg	0.18 mg
	NOX	270 kg	140 mg	0.62 mg
	VOC	54 kg	27 mg	0.12 mg
	Pb	0.18 kg	0.090 mg	0.42 µg
	PM10	46 kg	23 mg	110 µg
I, Insurance (Employees)	Energy	20 TJ	10 MJ	0.046 MJ
	GHG	1,600 mt GGE	820 g GGE	3.8 g GGE
	SO2	4,000 kg	2,000 mg	9.3 mg
	CO	18,000 kg	9,100 mg	42 mg
	NOX	4,600 kg	2,300 mg	10 mg
	VOC	3,400 kg	1,700 mg	7.8 mg
	Pb	-	-	-
	PM10	860 kg	430 mg	2,000 µg
I, Insurance (Facilities)	Energy	0.76 TJ	0.38 MJ	0.0018 MJ
	GHG	63 mt GGE	31 g GGE	0.14 g GGE
	SO2	150 kg	76 mg	0.35 mg
	CO	690 kg	340 mg	1.6 mg
	NOX	170 kg	86 mg	0.40 mg
	VOC	130 kg	64 mg	0.29 mg
	Pb	-	-	-
	PM10	33 kg	16 mg	75 µg
F, Supply Chain (Vehicles)	Energy	58 TJ	29 MJ	0.13 MJ
	GHG	1,100 mt GGE	550 g GGE	2.5 g GGE
	SO2	13,000 kg	6,700 mg	31 mg
	CO	3,800 kg	1,900 mg	8.7 mg
	NOX	3,800 kg	1,900 mg	8.8 mg
	VOC	140 kg	72 mg	0.33 mg
	Pb	0.031 kg	0.015 mg	0.070 µg
	PM10	110 kg	53 mg	250 µg
F, T&D Losses (Vehicles)	Energy	35 TJ	18 MJ	0.081 MJ
	GHG	370 mt GGE	190 g GGE	0.85 g GGE
	SO2	1,900 kg	930 mg	4.3 mg
	CO	520 kg	260 mg	1.2 mg
	NOX	510 kg	250 mg	1.2 mg
	VOC	19 kg	9.3 mg	0.043 mg
	Pb	0.022 kg	0.011 mg	0.050 µg
	PM10	23 kg	11 mg	53 µg
F, Supply Chain (Infrastructure)	Energy	17 TJ	8.4 MJ	0.039 MJ
	GHG	320 mt GGE	160 g GGE	0.74 g GGE
	SO2	3,900 kg	1,900 mg	9.0 mg
	CO	1,100 kg	550 mg	2.5 mg
	NOX	1,100 kg	550 mg	2.5 mg
	VOC	42 kg	21 mg	0.096 mg
	Pb	0.0089 kg	0.0044 mg	0.020 µg
	PM10	31 kg	16 mg	72 µg
F, T&D Losses (Infrastructure)	Energy	10 TJ	5.1 MJ	0.024 MJ
	GHG	110 mt GGE	54 g GGE	0.25 g GGE
	SO2	540 kg	270 mg	1.2 mg
	CO	150 kg	76 mg	0.35 mg
	NOX	150 kg	74 mg	0.34 mg
	VOC	5.4 kg	2.7 mg	0.012 mg
	Pb	0.0064 kg	0.0032 mg	0.015 µg
	PM10	6.7 kg	3.3 mg	15 µg

6.11 NY/NJ PATH Metro Life-cycle Inventory

Table 23 – NY/NJ PATH Metro Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	17 TJ	11 MJ	0.067 MJ
	GHG	1,000 mt GGE	640 g GGE	4.1 g GGE
	SO2	3,800 kg	2,400 mg	15 mg
	CO	1,200 kg	740 mg	4.7 mg
	NOX	2,100 kg	1,300 mg	8.4 mg
	VOC	530 kg	330 mg	2.1 mg
	Pb	4.4 kg	2.8 mg	18 µg
	PM10	1,100 kg	680 mg	4,300 µg
V, Operation (Active)	Energy	170 TJ	100 MJ	0.66 MJ
	GHG	15,000 mt GGE	9,200 g GGE	59 g GGE
	SO2	85,000 kg	53,000 mg	340 mg
	CO	2,800 kg	1,800 mg	11 mg
	NOX	15,000 kg	9,400 mg	60 mg
	VOC	930 kg	590 mg	3.7 mg
	Pb	0.73 kg	0.46 mg	2.9 µg
	PM10	690 kg	440 mg	2,800 µg
V, Operation (Idling)	Energy	85 TJ	53 MJ	0.34 MJ
	GHG	7,500 mt GGE	4,700 g GGE	30 g GGE
	SO2	43,000 kg	27,000 mg	170 mg
	CO	1,400 kg	910 mg	5.7 mg
	NOX	7,600 kg	4,800 mg	30 mg
	VOC	480 kg	300 mg	1.9 mg
	Pb	0.37 kg	0.23 mg	1.5 µg
	PM10	350 kg	220 mg	1,400 µg
V, Operation (HVAC)	Energy	23 TJ	14 MJ	0.092 MJ
	GHG	2,000 mt GGE	1,300 g GGE	8.1 g GGE
	SO2	12,000 kg	7,400 mg	47 mg
	CO	390 kg	250 mg	1.6 mg
	NOX	2,100 kg	1,300 mg	8.3 mg
	VOC	130 kg	81 mg	0.52 mg
	Pb	0.10 kg	0.064 mg	0.40 µg
	PM10	96 kg	60 mg	380 µg
V, Maintenance	Energy	14 TJ	8.6 MJ	0.055 MJ
	GHG	630 mt GGE	390 g GGE	2.5 g GGE
	SO2	1,700 kg	1,100 mg	6.9 mg
	CO	1,600 kg	980 mg	6.2 mg
	NOX	1,500 kg	920 mg	5.8 mg
	VOC	2,300 kg	1,400 mg	9.0 mg
	Pb	6.1 kg	3.8 mg	24 µg
	PM10	430 kg	270 mg	1,700 µg
V, Maintenance (Cleaning)	Energy	0.25 TJ	0.15 MJ	0.00098 MJ
	GHG	10 mt GGE	6.4 g GGE	0.041 g GGE
	SO2	51 kg	32 mg	0.20 mg
	CO	14 kg	9.0 mg	0.057 mg
	NOX	14 kg	8.8 mg	0.056 mg
	VOC	0.51 kg	0.32 mg	0.0020 mg
	Pb	0.00060 kg	0.00038 mg	0.0024 µg
	PM10	0.63 kg	0.39 mg	2.5 µg
V, Maintenance (Flooring)	Energy	0.41 TJ	0.26 MJ	0.0016 MJ
	GHG	31 mt GGE	19 g GGE	0.12 g GGE
	SO2	63 kg	40 mg	0.25 mg
	CO	230 kg	140 mg	0.90 mg
	NOX	57 kg	36 mg	0.23 mg
	VOC	52 kg	33 mg	0.21 mg
	Pb	-	-	-
	PM10	10 kg	6.5 mg	41 µg
V, Insurance (Employees)	Energy	23 TJ	15 MJ	0.093 MJ
	GHG	1,900 mt GGE	1,200 g GGE	7.6 g GGE
	SO2	4,700 kg	2,900 mg	19 mg
	CO	21,000 kg	13,000 mg	84 mg
	NOX	5,300 kg	3,300 mg	21 mg
	VOC	3,900 kg	2,500 mg	16 mg
	Pb	-	-	-
	PM10	1,000 kg	630 mg	4,000 µg
V, Insurance (Vehicles)	Energy	3.8 TJ	2.4 MJ	0.015 MJ
	GHG	310 mt GGE	200 g GGE	1.2 g GGE
	SO2	770 kg	480 mg	3.1 mg
	CO	3,500 kg	2,200 mg	14 mg
	NOX	870 kg	540 mg	3.4 mg
	VOC	640 kg	400 mg	2.6 mg
	Pb	-	-	-
	PM10	160 kg	100 mg	650 µg

Table 24 – NY/NJ PATH Metro Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	33 TJ	21 MJ	0.13 MJ
	GHG	3,300 mt GGE	2,100 g GGE	13 g GGE
	SO2	10,000 kg	6,300 mg	40 mg
	CO	27,000 kg	17,000 mg	110 mg
	NOX	14,000 kg	8,600 mg	55 mg
	VOC	8,700 kg	5,500 mg	35 mg
	Pb	1.5 kg	0.97 mg	6.1 µg
	PM10	1,800 kg	1,100 mg	7,000 µg
I, Station Lighting	Energy	25 TJ	16 MJ	0.100 MJ
	GHG	2,200 mt GGE	1,400 g GGE	8.8 g GGE
	SO2	13,000 kg	8,100 mg	51 mg
	CO	430 kg	270 mg	1.7 mg
	NOX	2,300 kg	1,400 mg	9.0 mg
	VOC	140 kg	89 mg	0.56 mg
	Pb	0.11 kg	0.069 mg	0.44 µg
	PM10	100 kg	66 mg	420 µg
I, Station Escalators	Energy	1.0 TJ	0.63 MJ	0.0040 MJ
	GHG	89 mt GGE	56 g GGE	0.35 g GGE
	SO2	510 kg	320 mg	2.0 mg
	CO	17 kg	11 mg	0.068 mg
	NOX	90 kg	57 mg	0.36 mg
	VOC	5.6 kg	3.5 mg	0.022 mg
	Pb	0.0044 kg	0.0028 mg	0.018 µg
	PM10	4.2 kg	2.6 mg	17 µg
I, Station Train Control	Energy	6.4 TJ	4.0 MJ	0.025 MJ
	GHG	560 mt GGE	360 g GGE	2.2 g GGE
	SO2	3,300 kg	2,100 mg	13 mg
	CO	110 kg	68 mg	0.43 mg
	NOX	570 kg	360 mg	2.3 mg
	VOC	36 kg	23 mg	0.14 mg
	Pb	0.028 kg	0.018 mg	0.11 µg
	PM10	27 kg	17 mg	110 µg
I, Station Parking Lighting	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
I, Station Miscellaneous	Energy	2.0 TJ	1.3 MJ	0.0081 MJ
	GHG	180 mt GGE	110 g GGE	0.72 g GGE
	SO2	1,000 kg	650 mg	4.1 mg
	CO	35 kg	22 mg	0.14 mg
	NOX	180 kg	110 mg	0.73 mg
	VOC	11 kg	7.2 mg	0.045 mg
	Pb	0.0089 kg	0.0056 mg	0.035 µg
	PM10	8.5 kg	5.3 mg	34 µg
I, Station Maintenance	Energy	3.3 TJ	2.1 MJ	0.013 MJ
	GHG	330 mt GGE	210 g GGE	1.3 g GGE
	SO2	1,000 kg	630 mg	4.0 mg
	CO	2,700 kg	1,700 mg	11 mg
	NOX	1,400 kg	860 mg	5.5 mg
	VOC	870 kg	550 mg	3.5 mg
	Pb	0.15 kg	0.097 mg	0.61 µg
	PM10	180 kg	110 mg	700 µg
I, Station Cleaning	Energy	0.25 TJ	0.15 MJ	0.00098 MJ
	GHG	10 mt GGE	6.4 g GGE	0.041 g GGE
	SO2	51 kg	32 mg	0.20 mg
	CO	14 kg	9.0 mg	0.057 mg
	NOX	14 kg	8.8 mg	0.056 mg
	VOC	0.51 kg	0.32 mg	0.0020 mg
	Pb	0.00060 kg	0.00038 mg	0.0024 µg
	PM10	0.63 kg	0.39 mg	2.5 µg
I, Station Parking	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-

(Table 24 continued on the following page…)

Table 24 – NY/NJ PATH Metro Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	2.1 TJ	1.3 MJ	0.0085 MJ
	GHG	200 mt GGE	120 g GGE	0.79 g GGE
	SO2	510 kg	320 mg	2.0 mg
	CO	1,700 kg	1,100 mg	6.8 mg
	NOX	600 kg	380 mg	2.4 mg
	VOC	410 kg	260 mg	1.6 mg
	Pb	0.44 kg	0.27 mg	1.7 µg
	PM10	130 kg	82 mg	520 µg
I, Track Maintenance	Energy	3.3 TJ	2.1 MJ	0.013 MJ
	GHG	140 mt GGE	86 g GGE	0.54 g GGE
	SO2	130 kg	80 mg	0.51 mg
	CO	66 kg	41 mg	0.26 mg
	NOX	230 kg	140 mg	0.90 mg
	VOC	44 kg	28 mg	0.18 mg
	Pb	0.15 kg	0.095 mg	0.60 µg
	PM10	38 kg	24 mg	150 µg
I, Insurance (Employees)	Energy	20 TJ	12 MJ	0.078 MJ
	GHG	1,600 mt GGE	1,000 g GGE	6.4 g GGE
	SO2	3,900 kg	2,500 mg	16 mg
	CO	18,000 kg	11,000 mg	71 mg
	NOX	4,400 kg	2,800 mg	18 mg
	VOC	3,300 kg	2,100 mg	13 mg
	Pb	-	-	-
	PM10	840 kg	530 mg	3,300 µg
I, Insurance (Facilities)	Energy	3.2 TJ	2.0 MJ	0.013 MJ
	GHG	260 mt GGE	160 g GGE	1.0 g GGE
	SO2	640 kg	410 mg	2.6 mg
	CO	2,900 kg	1,800 mg	12 mg
	NOX	730 kg	460 mg	2.9 mg
	VOC	540 kg	340 mg	2.1 mg
	Pb	-	-	-
	PM10	140 kg	86 mg	550 µg
F, Supply Chain (Vehicles)	Energy	3.6 TJ	2.2 MJ	0.014 MJ
	GHG	68 mt GGE	43 g GGE	0.27 g GGE
	SO2	830 kg	520 mg	3.3 mg
	CO	230 kg	150 mg	0.93 mg
	NOX	230 kg	150 mg	0.94 mg
	VOC	8.9 kg	5.6 mg	0.035 mg
	Pb	0.0019 kg	0.0012 mg	0.0075 µg
	PM10	6.6 kg	4.1 mg	26 µg
F, T&D Losses (Vehicles)	Energy	29 TJ	18 MJ	0.12 MJ
	GHG	270 mt GGE	170 g GGE	1.1 g GGE
	SO2	1,600 kg	990 mg	6.3 mg
	CO	53 kg	33 mg	0.21 mg
	NOX	280 kg	170 mg	1.1 mg
	VOC	17 kg	11 mg	0.069 mg
	Pb	0.014 kg	0.0085 mg	0.054 µg
	PM10	13 kg	8.1 mg	51 µg
F, Supply Chain (Infrastructure)	Energy	0.45 TJ	0.28 MJ	0.0018 MJ
	GHG	8.6 mt GGE	5.4 g GGE	0.034 g GGE
	SO2	100 kg	66 mg	0.42 mg
	CO	29 kg	18 mg	0.12 mg
	NOX	30 kg	19 mg	0.12 mg
	VOC	1.1 kg	0.70 mg	0.0045 mg
	Pb	0.00024 kg	0.00015 mg	0.00095 µg
	PM10	0.83 kg	0.52 mg	3.3 µg
F, T&D Losses (Infrastructure)	Energy	3.7 TJ	2.3 MJ	0.015 MJ
	GHG	34 mt GGE	22 g GGE	0.14 g GGE
	SO2	200 kg	130 mg	0.79 mg
	CO	6.6 kg	4.2 mg	0.026 mg
	NOX	35 kg	22 mg	0.14 mg
	VOC	2.2 kg	1.4 mg	0.0087 mg
	Pb	0.0017 kg	0.0011 mg	0.0068 µg
	PM10	1.6 kg	1.0 mg	6.5 µg

6.12 Newark Light Rail Life-cycle Inventory

Table 25 – Newark Light Rail Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	0.77 TJ	0.38 MJ	0.016 MJ
	GHG	39 mt GGE	19 g GGE	0.81 g GGE
	SO2	190 kg	97 mg	4.1 mg
	CO	310 kg	160 mg	6.7 mg
	NOX	110 kg	55 mg	2.4 mg
	VOC	28 kg	14 mg	0.60 mg
	Pb	0.77 kg	0.38 mg	16 µg
	PM10	77 kg	38 mg	1,600 µg
V, Operation (Active)	Energy	14 TJ	7.1 MJ	0.30 MJ
	GHG	1,300 mt GGE	630 g GGE	27 g GGE
	SO2	7,400 kg	3,700 mg	160 mg
	CO	240 kg	120 mg	5.2 mg
	NOX	1,300 kg	640 mg	27 mg
	VOC	81 kg	40 mg	1.7 mg
	Pb	0.063 kg	0.031 mg	1.3 µg
	PM10	60 kg	30 mg	1,300 µg
V, Operation (Idling)	Energy	7.3 TJ	3.6 MJ	0.15 MJ
	GHG	650 mt GGE	320 g GGE	14 g GGE
	SO2	3,700 kg	1,900 mg	79 mg
	CO	120 kg	62 mg	2.6 mg
	NOX	660 kg	330 mg	14 mg
	VOC	41 kg	20 mg	0.87 mg
	Pb	0.032 kg	0.016 mg	0.68 µg
	PM10	30 kg	15 mg	640 µg
V, Operation (HVAC)	Energy	2.2 TJ	1.1 MJ	0.046 MJ
	GHG	190 mt GGE	95 g GGE	4.0 g GGE
	SO2	1,100 kg	550 mg	23 mg
	CO	37 kg	18 mg	0.78 mg
	NOX	190 kg	97 mg	4.1 mg
	VOC	12 kg	6.0 mg	0.26 mg
	Pb	0.0095 kg	0.0047 mg	0.20 µg
	PM10	9.0 kg	4.5 mg	190 µg
V, Maintenance	Energy	0.16 TJ	0.078 MJ	0.0033 MJ
	GHG	7.8 mt GGE	3.9 g GGE	0.16 g GGE
	SO2	22 kg	11 mg	0.47 mg
	CO	27 kg	13 mg	0.57 mg
	NOX	24 kg	12 mg	0.52 mg
	VOC	15 kg	7.5 mg	0.32 mg
	Pb	0.16 kg	0.077 mg	3.3 µg
	PM10	6.5 kg	3.2 mg	140 µg
V, Maintenance (Cleaning)	Energy	0.013 TJ	0.0062 MJ	0.00026 MJ
	GHG	0.52 mt GGE	0.26 g GGE	0.011 g GGE
	SO2	2.6 kg	1.3 mg	0.055 mg
	CO	0.73 kg	0.36 mg	0.015 mg
	NOX	0.71 kg	0.35 mg	0.015 mg
	VOC	0.026 kg	0.013 mg	0.00055 mg
	Pb	0.000031 kg	0.000015 mg	0.00065 µg
	PM10	0.032 kg	0.016 mg	0.68 µg
V, Maintenance (Flooring)	Energy	0.021 TJ	0.010 MJ	0.00044 MJ
	GHG	1.6 mt GGE	0.79 g GGE	0.033 g GGE
	SO2	3.2 kg	1.6 mg	0.068 mg
	CO	12 kg	5.7 mg	0.24 mg
	NOX	2.9 kg	1.5 mg	0.062 mg
	VOC	2.6 kg	1.3 mg	0.056 mg
	Pb	-	-	-
	PM10	0.53 kg	0.26 mg	11 µg
V, Insurance (Employees)	Energy	4.4 TJ	2.2 MJ	0.093 MJ
	GHG	360 mt GGE	180 g GGE	7.6 g GGE
	SO2	880 kg	440 mg	19 mg
	CO	4,000 kg	2,000 mg	84 mg
	NOX	990 kg	490 mg	21 mg
	VOC	740 kg	370 mg	16 mg
	Pb	-	-	-
	PM10	190 kg	93 mg	4,000 µg
V, Insurance (Vehicles)	Energy	0.16 TJ	0.082 MJ	0.0035 MJ
	GHG	13 mt GGE	6.7 g GGE	0.29 g GGE
	SO2	33 kg	16 mg	0.70 mg
	CO	150 kg	74 mg	3.2 mg
	NOX	37 kg	19 mg	0.79 mg
	VOC	28 kg	14 mg	0.59 mg
	Pb	-	-	-
	PM10	7.0 kg	3.5 mg	150 µg

Table 26 – Newark Light Rail Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	21 TJ	11 MJ	0.45 MJ
	GHG	2,100 mt GGE	1,100 g GGE	45 g GGE
	SO2	6,500 kg	3,200 mg	140 mg
	CO	18,000 kg	8,700 mg	370 mg
	NOX	8,900 kg	4,400 mg	190 mg
	VOC	5,600 kg	2,800 mg	120 mg
	Pb	0.99 kg	0.49 mg	21 µg
	PM10	1,100 kg	570 mg	24,000 µg
I, Station Lighting	Energy	16 TJ	8.0 MJ	0.34 MJ
	GHG	1,400 mt GGE	710 g GGE	30 g GGE
	SO2	8,300 kg	4,100 mg	170 mg
	CO	280 kg	140 mg	5.8 mg
	NOX	1,500 kg	720 mg	31 mg
	VOC	91 kg	45 mg	1.9 mg
	Pb	0.071 kg	0.035 mg	1.5 µg
	PM10	67 kg	33 mg	1,400 µg
I, Station Escalators	Energy	4.6 TJ	2.3 MJ	0.098 MJ
	GHG	410 mt GGE	200 g GGE	8.7 g GGE
	SO2	2,400 kg	1,200 mg	50 mg
	CO	79 kg	39 mg	1.7 mg
	NOX	420 kg	210 mg	8.8 mg
	VOC	26 kg	13 mg	0.55 mg
	Pb	0.020 kg	0.010 mg	0.43 µg
	PM10	19 kg	9.6 mg	410 µg
I, Station Train Control	Energy	5.1 TJ	2.5 MJ	0.11 MJ
	GHG	450 mt GGE	230 g GGE	9.6 g GGE
	SO2	2,600 kg	1,300 mg	55 mg
	CO	87 kg	43 mg	1.8 mg
	NOX	460 kg	230 mg	9.8 mg
	VOC	29 kg	14 mg	0.61 mg
	Pb	0.022 kg	0.011 mg	0.48 µg
	PM10	21 kg	11 mg	450 µg
I, Station Parking Lighting	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
I, Station Miscellaneous	Energy	7.8 TJ	3.9 MJ	0.16 MJ
	GHG	690 mt GGE	340 g GGE	15 g GGE
	SO2	4,000 kg	2,000 mg	84 mg
	CO	130 kg	66 mg	2.8 mg
	NOX	700 kg	350 mg	15 mg
	VOC	44 kg	22 mg	0.93 mg
	Pb	0.034 kg	0.017 mg	0.72 µg
	PM10	33 kg	16 mg	690 µg
I, Station Maintenance	Energy	2.1 TJ	1.1 MJ	0.045 MJ
	GHG	210 mt GGE	110 g GGE	4.5 g GGE
	SO2	650 kg	320 mg	14 mg
	CO	1,800 kg	870 mg	37 mg
	NOX	890 kg	440 mg	19 mg
	VOC	560 kg	280 mg	12 mg
	Pb	0.099 kg	0.049 mg	2.1 µg
	PM10	110 kg	57 mg	2,400 µg
I, Station Cleaning	Energy	0.013 TJ	0.0062 MJ	0.00026 MJ
	GHG	0.52 mt GGE	0.26 g GGE	0.011 g GGE
	SO2	2.6 kg	1.3 mg	0.055 mg
	CO	0.73 kg	0.36 mg	0.015 mg
	NOX	0.71 kg	0.35 mg	0.015 mg
	VOC	0.026 kg	0.013 mg	0.00055 mg
	Pb	0.000031 kg	0.000015 mg	0.00065 µg
	PM10	0.032 kg	0.016 mg	0.68 µg
I, Station Parking	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-

(Table 26 continued on the following page…)

Table 26 – Newark Light Rail Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	2.3 TJ	1.1 MJ	0.049 MJ
	GHG	210 mt GGE	110 g GGE	4.5 g GGE
	SO2	500 kg	250 mg	11 mg
	CO	1,900 kg	920 mg	39 mg
	NOX	560 kg	280 mg	12 mg
	VOC	370 kg	190 mg	7.9 mg
	Pb	0.63 kg	0.31 mg	13 µg
	PM10	150 kg	76 mg	3,200 µg
I, Track Maintenance	Energy	8.6 TJ	4.3 MJ	0.18 MJ
	GHG	630 mt GGE	310 g GGE	13 g GGE
	SO2	420 kg	210 mg	8.8 mg
	CO	1,400 kg	700 mg	30 mg
	NOX	2,900 kg	1,400 mg	62 mg
	VOC	300 kg	150 mg	6.4 mg
	Pb	-	-	-
	PM10	300 kg	150 mg	6,400 µg
I, Insurance (Employees)	Energy	1.6 TJ	0.80 MJ	0.034 MJ
	GHG	130 mt GGE	65 g GGE	2.8 g GGE
	SO2	320 kg	160 mg	6.8 mg
	CO	1,500 kg	720 mg	31 mg
	NOX	360 kg	180 mg	7.7 mg
	VOC	270 kg	130 mg	5.7 mg
	Pb	-	-	-
	PM10	69 kg	34 mg	1,500 µg
I, Insurance (Facilities)	Energy	0.060 TJ	0.030 MJ	0.0013 MJ
	GHG	4.9 mt GGE	2.5 g GGE	0.10 g GGE
	SO2	12 kg	6.0 mg	0.26 mg
	CO	55 kg	27 mg	1.2 mg
	NOX	14 kg	6.8 mg	0.29 mg
	VOC	10 kg	5.0 mg	0.21 mg
	Pb	-	-	-
	PM10	2.6 kg	1.3 mg	55 µg
F, Supply Chain (Vehicles)	Energy	0.31 TJ	0.15 MJ	0.0065 MJ
	GHG	5.9 mt GGE	2.9 g GGE	0.12 g GGE
	SO2	72 kg	36 mg	1.5 mg
	CO	20 kg	10 mg	0.43 mg
	NOX	20 kg	10 mg	0.43 mg
	VOC	0.77 kg	0.38 mg	0.016 mg
	Pb	0.00016 kg	0.000082 mg	0.0035 µg
	PM10	0.57 kg	0.29 mg	12 µg
F, T&D Losses (Vehicles)	Energy	2.5 TJ	1.3 MJ	0.053 MJ
	GHG	24 mt GGE	12 g GGE	0.50 g GGE
	SO2	140 kg	68 mg	2.9 mg
	CO	4.6 kg	2.3 mg	0.097 mg
	NOX	24 kg	12 mg	0.51 mg
	VOC	1.5 kg	0.75 mg	0.032 mg
	Pb	0.0012 kg	0.00059 mg	0.025 µg
	PM10	1.1 kg	0.56 mg	24 µg
F, Supply Chain (Infrastructure)	Energy	0.44 TJ	0.22 MJ	0.0092 MJ
	GHG	8.4 mt GGE	4.2 g GGE	0.18 g GGE
	SO2	100 kg	51 mg	2.2 mg
	CO	29 kg	14 mg	0.61 mg
	NOX	29 kg	14 mg	0.61 mg
	VOC	1.1 kg	0.54 mg	0.023 mg
	Pb	0.00023 kg	0.00012 mg	0.0049 µg
	PM10	0.81 kg	0.40 mg	17 µg
F, T&D Losses (Infrastructure)	Energy	3.6 TJ	1.8 MJ	0.076 MJ
	GHG	34 mt GGE	17 g GGE	0.71 g GGE
	SO2	190 kg	97 mg	4.1 mg
	CO	6.5 kg	3.2 mg	0.14 mg
	NOX	34 kg	17 mg	0.72 mg
	VOC	2.1 kg	1.1 mg	0.045 mg
	Pb	0.0017 kg	0.00083 mg	0.035 µg
	PM10	1.6 kg	0.79 mg	33 µg

6.13 New York City Commuter Rail Life-cycle Inventory

Table 27 – New York City Commuter Rail Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	30 TJ	16 MJ	0.091 MJ
	GHG	1,800 mt GGE	950 g GGE	5.5 g GGE
	SO2	6,900 kg	3,600 mg	21 mg
	CO	2,100 kg	1,100 mg	6.3 mg
	NOX	3,800 kg	2,000 mg	11 mg
	VOC	950 kg	500 mg	2.9 mg
	Pb	7.9 kg	4.1 mg	24 µg
	PM10	1,900 kg	1,000 mg	5,800 µg
V, Operation (Active)	Energy	270 TJ	140 MJ	0.80 MJ
	GHG	18,000 mt GGE	9,600 g GGE	56 g GGE
	SO2	81 kg	42 mg	0.24 mg
	CO	18,000 kg	9,300 mg	54 mg
	NOX	350,000 kg	180,000 mg	1,000 mg
	VOC	11,000 kg	5,600 mg	33 mg
	Pb	-	-	-
	PM10	9,300 kg	4,800 mg	28,000 µg
V, Operation (Idling)	Energy	36 TJ	19 MJ	0.11 MJ
	GHG	2,500 mt GGE	1,300 g GGE	7.5 g GGE
	SO2	11 kg	5.7 mg	0.033 mg
	CO	5,700 kg	3,000 mg	17 mg
	NOX	58,000 kg	30,000 mg	180 mg
	VOC	6,200 kg	3,200 mg	19 mg
	Pb	-	-	-
	PM10	1,600 kg	850 mg	4,900 µg
V, Operation (HVAC)	Energy	14 TJ	7.4 MJ	0.043 MJ
	GHG	990 mt GGE	510 g GGE	3.0 g GGE
	SO2	4.3 kg	2.3 mg	0.013 mg
	CO	960 kg	500 mg	2.9 mg
	NOX	18,000 kg	9,600 mg	56 mg
	VOC	580 kg	300 mg	1.7 mg
	Pb	-	-	-
	PM10	500 kg	260 mg	1,500 µg
V, Maintenance	Energy	25 TJ	13 MJ	0.074 MJ
	GHG	1,100 mt GGE	580 g GGE	3.4 g GGE
	SO2	3,100 kg	1,600 mg	9.3 mg
	CO	2,800 kg	1,500 mg	8.4 mg
	NOX	2,600 kg	1,400 mg	7.9 mg
	VOC	4,100 kg	2,100 mg	12 mg
	Pb	11 kg	5.7 mg	33 µg
	PM10	780 kg	410 mg	2,300 µg
V, Maintenance (Cleaning)	Energy	0.12 TJ	0.064 MJ	0.00037 MJ
	GHG	12 mt GGE	6.4 g GGE	0.037 g GGE
	SO2	61 kg	32 mg	0.18 mg
	CO	17 kg	9.0 mg	0.052 mg
	NOX	17 kg	8.7 mg	0.051 mg
	VOC	0.62 kg	0.32 mg	0.0019 mg
	Pb	0.00072 kg	0.00038 mg	0.0022 µg
	PM10	0.76 kg	0.39 mg	2.3 µg
V, Maintenance (Flooring)	Energy	5.9 TJ	3.1 MJ	0.018 MJ
	GHG	470 mt GGE	240 g GGE	1.4 g GGE
	SO2	850 kg	440 mg	2.5 mg
	CO	4,400 kg	2,300 mg	13 mg
	NOX	850 kg	440 mg	2.5 mg
	VOC	760 kg	400 mg	2.3 mg
	Pb	0.41 kg	0.21 mg	1.2 µg
	PM10	290 kg	150 mg	880 µg
V, Insurance (Employees)	Energy	28 TJ	14 MJ	0.083 MJ
	GHG	2,300 mt GGE	1,200 g GGE	6.8 g GGE
	SO2	5,600 kg	2,900 mg	17 mg
	CO	25,000 kg	13,000 mg	76 mg
	NOX	6,300 kg	3,300 mg	19 mg
	VOC	4,700 kg	2,400 mg	14 mg
	Pb	-	-	-
	PM10	1,200 kg	620 mg	3,600 µg
V, Insurance (Vehicles)	Energy	2.6 TJ	1.3 MJ	0.0077 MJ
	GHG	210 mt GGE	110 g GGE	0.63 g GGE
	SO2	510 kg	270 mg	1.5 mg
	CO	2,300 kg	1,200 mg	7.0 mg
	NOX	580 kg	300 mg	1.7 mg
	VOC	430 kg	220 mg	1.3 mg
	Pb	-	-	-
	PM10	110 kg	57 mg	330 µg

Table 28 – New York City Commuter Rail Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	3.7 TJ	1.9 MJ	0.011 MJ
	GHG	370 mt GGE	190 g GGE	1.1 g GGE
	SO2	1,100 kg	580 mg	3.4 mg
	CO	3,000 kg	1,600 mg	9.1 mg
	NOX	1,500 kg	790 mg	4.6 mg
	VOC	970 kg	500 mg	2.9 mg
	Pb	0.17 kg	0.089 mg	0.51 µg
	PM10	200 kg	100 mg	590 µg
I, Station Lighting	Energy	9.7 TJ	5.1 MJ	0.029 MJ
	GHG	970 mt GGE	500 g GGE	2.9 g GGE
	SO2	4,800 kg	2,500 mg	15 mg
	CO	1,400 kg	710 mg	4.1 mg
	NOX	1,300 kg	690 mg	4.0 mg
	VOC	49 kg	25 mg	0.15 mg
	Pb	0.057 kg	0.030 mg	0.17 µg
	PM10	60 kg	31 mg	180 µg
I, Station Escalators	Energy	2.2 TJ	1.1 MJ	0.0065 MJ
	GHG	220 mt GGE	110 g GGE	0.65 g GGE
	SO2	1,100 kg	560 mg	3.2 mg
	CO	300 kg	160 mg	0.91 mg
	NOX	300 kg	150 mg	0.89 mg
	VOC	11 kg	5.6 mg	0.033 mg
	Pb	0.013 kg	0.0066 mg	0.038 µg
	PM10	13 kg	6.9 mg	40 µg
I, Station Train Control	Energy	13 TJ	6.6 MJ	0.038 MJ
	GHG	1,300 mt GGE	660 g GGE	3.8 g GGE
	SO2	6,300 kg	3,300 mg	19 mg
	CO	1,800 kg	920 mg	5.3 mg
	NOX	1,700 kg	900 mg	5.2 mg
	VOC	63 kg	33 mg	0.19 mg
	Pb	0.075 kg	0.039 mg	0.22 µg
	PM10	78 kg	41 mg	230 µg
I, Station Parking Lighting	Energy	37 TJ	19 MJ	0.11 MJ
	GHG	3,700 mt GGE	1,900 g GGE	11 g GGE
	SO2	19,000 kg	9,700 mg	56 mg
	CO	5,200 kg	2,700 mg	16 mg
	NOX	5,100 kg	2,600 mg	15 mg
	VOC	190 kg	97 mg	0.56 mg
	Pb	0.22 kg	0.11 mg	0.66 µg
	PM10	230 kg	120 mg	690 µg
I, Station Miscellaneous	Energy	2.2 TJ	1.2 MJ	0.0067 MJ
	GHG	220 mt GGE	120 g GGE	0.67 g GGE
	SO2	1,100 kg	580 mg	3.4 mg
	CO	310 kg	160 mg	0.94 mg
	NOX	310 kg	160 mg	0.92 mg
	VOC	11 kg	5.8 mg	0.034 mg
	Pb	0.013 kg	0.0068 mg	0.040 µg
	PM10	14 kg	7.2 mg	41 µg
I, Station Maintenance	Energy	0.37 TJ	0.19 MJ	0.0011 MJ
	GHG	37 mt GGE	19 g GGE	0.11 g GGE
	SO2	110 kg	58 mg	0.34 mg
	CO	300 kg	160 mg	0.91 mg
	NOX	150 kg	79 mg	0.46 mg
	VOC	97 kg	50 mg	0.29 mg
	Pb	0.017 kg	0.0089 mg	0.051 µg
	PM10	20 kg	10 mg	59 µg
I, Station Cleaning	Energy	0.12 TJ	0.064 MJ	0.00037 MJ
	GHG	12 mt GGE	6.4 g GGE	0.037 g GGE
	SO2	61 kg	32 mg	0.18 mg
	CO	17 kg	9.0 mg	0.052 mg
	NOX	17 kg	8.7 mg	0.051 mg
	VOC	0.62 kg	0.32 mg	0.0019 mg
	Pb	0.00072 kg	0.00038 mg	0.0022 µg
	PM10	0.76 kg	0.39 mg	2.3 µg
I, Station Parking	Energy	7.2 TJ	3.8 MJ	0.022 MJ
	GHG	600 mt GGE	310 g GGE	1.8 g GGE
	SO2	1,200 kg	610 mg	3.6 mg
	CO	1,900 kg	980 mg	5.6 mg
	NOX	3,100 kg	1,600 mg	9.2 mg
	VOC	3,600 kg	1,900 mg	11 mg
	Pb	0.34 kg	0.18 mg	1.0 µg
	PM10	1,600 kg	840 mg	4,900 µg

(Table 28 continued on the following page…)

Table 28 – New York City Commuter Rail Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	1.7 TJ	0.90 MJ	0.0052 MJ
	GHG	160 mt GGE	81 g GGE	0.47 g GGE
	SO2	290 kg	150 mg	0.87 mg
	CO	1,600 kg	840 mg	4.8 mg
	NOX	270 kg	140 mg	0.81 mg
	VOC	190 kg	96 mg	0.56 mg
	Pb	0.73 kg	0.38 mg	2.2 µg
	PM10	160 kg	86 mg	490 µg
I, Track Maintenance	Energy	16 TJ	8.2 MJ	0.048 MJ
	GHG	660 mt GGE	340 g GGE	2.0 g GGE
	SO2	610 kg	320 mg	1.8 mg
	CO	320 kg	160 mg	0.95 mg
	NOX	1,100 kg	560 mg	3.3 mg
	VOC	210 kg	110 mg	0.64 mg
	Pb	0.72 kg	0.38 mg	2.2 µg
	PM10	180 kg	96 mg	560 µg
I, Insurance (Employees)	Energy	13 TJ	6.8 MJ	0.039 MJ
	GHG	1,100 mt GGE	560 g GGE	3.2 g GGE
	SO2	2,600 kg	1,400 mg	7.9 mg
	CO	12,000 kg	6,200 mg	36 mg
	NOX	3,000 kg	1,500 mg	8.9 mg
	VOC	2,200 kg	1,100 mg	6.6 mg
	Pb	-	-	-
	PM10	560 kg	290 mg	1,700 µg
I, Insurance (Facilities)	Energy	1.2 TJ	0.63 MJ	0.0036 MJ
	GHG	99 mt GGE	51 g GGE	0.30 g GGE
	SO2	240 kg	130 mg	0.73 mg
	CO	1,100 kg	570 mg	3.3 mg
	NOX	270 kg	140 mg	0.82 mg
	VOC	200 kg	110 mg	0.61 mg
	Pb	-	-	-
	PM10	51 kg	27 mg	150 µg
F, Supply Chain (Vehicles)	Energy	42 TJ	22 MJ	0.13 MJ
	GHG	3,800 mt GGE	2,000 g GGE	11 g GGE
	SO2	7,100 kg	3,700 mg	21 mg
	CO	10,000 kg	5,400 mg	31 mg
	NOX	6,200 kg	3,200 mg	19 mg
	VOC	4,500 kg	2,400 mg	14 mg
	Pb	-	-	-
	PM10	1,000 kg	520 mg	3,000 µg
F, T&D Losses (Vehicles)	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
F, Supply Chain (Infrastructure)	Energy	11 TJ	5.8 MJ	0.034 MJ
	GHG	210 mt GGE	110 g GGE	0.64 g GGE
	SO2	2,600 kg	1,400 mg	7.8 mg
	CO	730 kg	380 mg	2.2 mg
	NOX	740 kg	380 mg	2.2 mg
	VOC	28 kg	15 mg	0.084 mg
	Pb	0.0059 kg	0.0031 mg	0.018 µg
	PM10	21 kg	11 mg	62 µg
F, T&D Losses (Infrastructure)	Energy	6.8 TJ	3.5 MJ	0.020 MJ
	GHG	72 mt GGE	37 g GGE	0.22 g GGE
	SO2	360 kg	190 mg	1.1 mg
	CO	100 kg	53 mg	0.30 mg
	NOX	99 kg	51 mg	0.30 mg
	VOC	3.6 kg	1.9 mg	0.011 mg
	Pb	0.0042 kg	0.0022 mg	0.013 µg
	PM10	4.4 kg	2.3 mg	13 µg

6.14 Chicago Commuter Rail Life-cycle Inventory

Table 29 – Chicago Commuter Rail Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	30 TJ	22 MJ	0.096 MJ
	GHG	1,800 mt GGE	1,400 g GGE	5.8 g GGE
	SO2	6,900 kg	5,100 mg	22 mg
	CO	2,100 kg	1,500 mg	6.7 mg
	NOX	3,800 kg	2,800 mg	12 mg
	VOC	950 kg	700 mg	3.0 mg
	Pb	7.9 kg	5.9 mg	25 µg
	PM10	1,900 kg	1,400 mg	6,100 µg
V, Operation (Active)	Energy	190 TJ	140 MJ	0.60 MJ
	GHG	13,000 mt GGE	9,600 g GGE	41 g GGE
	SO2	57 kg	42 mg	0.18 mg
	CO	13,000 kg	9,300 mg	40 mg
	NOX	240,000 kg	180,000 mg	780 mg
	VOC	7,600 kg	5,600 mg	24 mg
	Pb	-	-	-
	PM10	6,600 kg	4,800 mg	21,000 µg
V, Operation (Idling)	Energy	25 TJ	19 MJ	0.081 MJ
	GHG	1,800 mt GGE	1,300 g GGE	5.6 g GGE
	SO2	7.7 kg	5.7 mg	0.024 mg
	CO	4,000 kg	3,000 mg	13 mg
	NOX	41,000 kg	30,000 mg	130 mg
	VOC	4,400 kg	3,200 mg	14 mg
	Pb	-	-	-
	PM10	1,200 kg	850 mg	3,700 µg
V, Operation (HVAC)	Energy	10 TJ	7.4 MJ	0.032 MJ
	GHG	700 mt GGE	510 g GGE	2.2 g GGE
	SO2	3.1 kg	2.3 mg	0.0097 mg
	CO	670 kg	500 mg	2.1 mg
	NOX	13,000 kg	9,600 mg	41 mg
	VOC	410 kg	300 mg	1.3 mg
	Pb	-	-	-
	PM10	350 kg	260 mg	1,100 µg
V, Maintenance	Energy	25 TJ	18 MJ	0.078 MJ
	GHG	1,100 mt GGE	830 g GGE	3.6 g GGE
	SO2	3,100 kg	2,300 mg	9.9 mg
	CO	2,800 kg	2,100 mg	8.9 mg
	NOX	2,600 kg	1,900 mg	8.3 mg
	VOC	4,100 kg	3,000 mg	13 mg
	Pb	11 kg	8.1 mg	35 µg
	PM10	780 kg	570 mg	2,500 µg
V, Maintenance (Cleaning)	Energy	0.13 TJ	0.094 MJ	0.00040 MJ
	GHG	18 mt GGE	13 g GGE	0.058 g GGE
	SO2	42 kg	31 mg	0.13 mg
	CO	4.9 kg	3.6 mg	0.016 mg
	NOX	28 kg	21 mg	0.089 mg
	VOC	0.34 kg	0.25 mg	0.0011 mg
	Pb	0.0019 kg	0.0014 mg	0.0061 µg
	PM10	0.88 kg	0.65 mg	2.8 µg
V, Maintenance (Flooring)	Energy	6.1 TJ	4.5 MJ	0.019 MJ
	GHG	480 mt GGE	360 g GGE	1.5 g GGE
	SO2	870 kg	650 mg	2.8 mg
	CO	4,600 kg	3,400 mg	14 mg
	NOX	870 kg	650 mg	2.8 mg
	VOC	790 kg	580 mg	2.5 mg
	Pb	0.42 kg	0.31 mg	1.3 µg
	PM10	300 kg	220 mg	960 µg
V, Insurance (Employees)	Energy	16 TJ	11 MJ	0.050 MJ
	GHG	1,300 mt GGE	940 g GGE	4.1 g GGE
	SO2	3,100 kg	2,300 mg	9.9 mg
	CO	14,000 kg	10,000 mg	45 mg
	NOX	3,500 kg	2,600 mg	11 mg
	VOC	2,600 kg	1,900 mg	8.3 mg
	Pb	-	-	-
	PM10	670 kg	490 mg	2,100 µg
V, Insurance (Vehicles)	Energy	2.0 TJ	1.5 MJ	0.0065 MJ
	GHG	170 mt GGE	120 g GGE	0.53 g GGE
	SO2	410 kg	300 mg	1.3 mg
	CO	1,800 kg	1,400 mg	5.9 mg
	NOX	460 kg	340 mg	1.5 mg
	VOC	340 kg	250 mg	1.1 mg
	Pb	-	-	-
	PM10	87 kg	64 mg	280 µg

Table 30 – Chicago Commuter Rail Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	7.4 TJ	5.5 MJ	0.023 MJ
	GHG	730 mt GGE	540 g GGE	2.3 g GGE
	SO2	2,200 kg	1,700 mg	7.1 mg
	CO	6,100 kg	4,500 mg	19 mg
	NOX	3,100 kg	2,300 mg	9.7 mg
	VOC	1,900 kg	1,400 mg	6.2 mg
	Pb	0.34 kg	0.25 mg	1.1 µg
	PM10	390 kg	290 mg	1,200 µg
I, Station Lighting	Energy	20 TJ	14 MJ	0.062 MJ
	GHG	2,800 mt GGE	2,100 g GGE	8.9 g GGE
	SO2	6,500 kg	4,800 mg	21 mg
	CO	760 kg	560 mg	2.4 mg
	NOX	4,300 kg	3,200 mg	14 mg
	VOC	52 kg	38 mg	0.17 mg
	Pb	0.29 kg	0.22 mg	0.93 µg
	PM10	130 kg	100 mg	430 µg
I, Station Escalators	Energy	4.4 TJ	3.2 MJ	0.014 MJ
	GHG	620 mt GGE	460 g GGE	2.0 g GGE
	SO2	1,400 kg	1,100 mg	4.6 mg
	CO	170 kg	120 mg	0.53 mg
	NOX	960 kg	710 mg	3.1 mg
	VOC	12 kg	8.5 mg	0.037 mg
	Pb	0.065 kg	0.048 mg	0.21 µg
	PM10	30 kg	22 mg	96 µg
I, Station Train Control	Energy	26 TJ	19 MJ	0.081 MJ
	GHG	3,600 mt GGE	2,700 g GGE	12 g GGE
	SO2	8,500 kg	6,300 mg	27 mg
	CO	990 kg	730 mg	3.1 mg
	NOX	5,700 kg	4,200 mg	18 mg
	VOC	68 kg	50 mg	0.22 mg
	Pb	0.38 kg	0.28 mg	1.2 µg
	PM10	180 kg	130 mg	560 µg
I, Station Parking Lighting	Energy	75 TJ	55 MJ	0.24 MJ
	GHG	11,000 mt GGE	7,900 g GGE	34 g GGE
	SO2	25,000 kg	18,000 mg	79 mg
	CO	2,900 kg	2,100 mg	9.2 mg
	NOX	17,000 kg	12,000 mg	53 mg
	VOC	200 kg	150 mg	0.63 mg
	Pb	1.1 kg	0.83 mg	3.6 µg
	PM10	520 kg	380 mg	1,600 µg
I, Station Miscellaneous	Energy	4.5 TJ	3.3 MJ	0.014 MJ
	GHG	640 mt GGE	480 g GGE	2.0 g GGE
	SO2	1,500 kg	1,100 mg	4.8 mg
	CO	170 kg	130 mg	0.55 mg
	NOX	1,000 kg	740 mg	3.2 mg
	VOC	12 kg	8.8 mg	0.038 mg
	Pb	0.068 kg	0.050 mg	0.22 µg
	PM10	31 kg	23 mg	99 µg
I, Station Maintenance	Energy	0.74 TJ	0.55 MJ	0.0023 MJ
	GHG	73 mt GGE	54 g GGE	0.23 g GGE
	SO2	220 kg	170 mg	0.71 mg
	CO	610 kg	450 mg	1.9 mg
	NOX	310 kg	230 mg	0.97 mg
	VOC	190 kg	140 mg	0.62 mg
	Pb	0.034 kg	0.025 mg	0.11 µg
	PM10	39 kg	29 mg	120 µg
I, Station Cleaning	Energy	0.13 TJ	0.094 MJ	0.00040 MJ
	GHG	18 mt GGE	13 g GGE	0.058 g GGE
	SO2	42 kg	31 mg	0.13 mg
	CO	4.9 kg	3.6 mg	0.016 mg
	NOX	28 kg	21 mg	0.089 mg
	VOC	0.34 kg	0.25 mg	0.0011 mg
	Pb	0.0019 kg	0.0014 mg	0.0061 µg
	PM10	0.88 kg	0.65 mg	2.8 µg
I, Station Parking	Energy	3.6 TJ	2.7 MJ	0.012 MJ
	GHG	300 mt GGE	220 g GGE	0.96 g GGE
	SO2	590 kg	440 mg	1.9 mg
	CO	940 kg	690 mg	3.0 mg
	NOX	1,500 kg	1,100 mg	4.9 mg
	VOC	1,800 kg	1,300 mg	5.8 mg
	Pb	0.17 kg	0.13 mg	0.55 µg
	PM10	810 kg	600 mg	2,600 µg

(Table 30 continued on the following page…)

Table 30 – Chicago Commuter Rail Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	3.0 TJ	2.2 MJ	0.0096 MJ
	GHG	280 mt GGE	200 g GGE	0.88 g GGE
	SO2	640 kg	470 mg	2.0 mg
	CO	2,700 kg	2,000 mg	8.5 mg
	NOX	700 kg	520 mg	2.2 mg
	VOC	500 kg	370 mg	1.6 mg
	Pb	0.85 kg	0.63 mg	2.7 µg
	PM10	240 kg	180 mg	760 µg
I, Track Maintenance	Energy	21 TJ	16 MJ	0.068 MJ
	GHG	890 mt GGE	650 g GGE	2.8 g GGE
	SO2	830 kg	610 mg	2.6 mg
	CO	430 kg	310 mg	1.4 mg
	NOX	1,500 kg	1,100 mg	4.6 mg
	VOC	290 kg	210 mg	0.91 mg
	Pb	0.98 kg	0.72 mg	3.1 µg
	PM10	250 kg	180 mg	790 µg
I, Insurance (Employees)	Energy	7.3 TJ	5.4 MJ	0.023 MJ
	GHG	600 mt GGE	440 g GGE	1.9 g GGE
	SO2	1,500 kg	1,100 mg	4.7 mg
	CO	6,700 kg	4,900 mg	21 mg
	NOX	1,700 kg	1,200 mg	5.3 mg
	VOC	1,200 kg	910 mg	3.9 mg
	Pb	-	-	-
	PM10	310 kg	230 mg	1,000 µg
I, Insurance (Facilities)	Energy	0.96 TJ	0.71 MJ	0.0031 MJ
	GHG	79 mt GGE	58 g GGE	0.25 g GGE
	SO2	190 kg	140 mg	0.61 mg
	CO	870 kg	640 mg	2.8 mg
	NOX	220 kg	160 mg	0.69 mg
	VOC	160 kg	120 mg	0.51 mg
	Pb	-	-	-
	PM10	41 kg	30 mg	130 µg
F, Supply Chain (Vehicles)	Energy	29 TJ	22 MJ	0.094 MJ
	GHG	2,700 mt GGE	2,000 g GGE	8.5 g GGE
	SO2	5,000 kg	3,700 mg	16 mg
	CO	7,400 kg	5,400 mg	23 mg
	NOX	4,400 kg	3,200 mg	14 mg
	VOC	3,200 kg	2,400 mg	10 mg
	Pb	-	-	-
	PM10	710 kg	520 mg	2,300 µg
F, T&D Losses (Vehicles)	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
F, Supply Chain (Infrastructure)	Energy	18 TJ	13 MJ	0.056 MJ
	GHG	340 mt GGE	250 g GGE	1.1 g GGE
	SO2	4,100 kg	3,000 mg	13 mg
	CO	320 kg	240 mg	1.0 mg
	NOX	1,200 kg	860 mg	3.7 mg
	VOC	44 kg	32 mg	0.14 mg
	Pb	0.0093 kg	0.0069 mg	0.030 µg
	PM10	33 kg	24 mg	100 µg
F, T&D Losses (Infrastructure)	Energy	14 TJ	10 MJ	0.044 MJ
	GHG	210 mt GGE	150 g GGE	0.66 g GGE
	SO2	480 kg	360 mg	1.5 mg
	CO	56 kg	41 mg	0.18 mg
	NOX	320 kg	240 mg	1.0 mg
	VOC	3.9 kg	2.9 mg	0.012 mg
	Pb	0.022 kg	0.016 mg	0.069 µg
	PM10	10 kg	7.4 mg	32 µg

6.15 Chicago Metro Life-cycle Inventory

Table 31 – Chicago Metro Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	20 TJ	7.7 MJ	0.084 MJ
	GHG	1,200 mt GGE	470 g GGE	5.1 g GGE
	SO2	4,600 kg	1,800 mg	19 mg
	CO	1,400 kg	530 mg	5.8 mg
	NOX	2,500 kg	960 mg	11 mg
	VOC	640 kg	240 mg	2.7 mg
	Pb	5.3 kg	2.0 mg	22 µg
	PM10	1,300 kg	490 mg	5,400 µg
V, Operation (Active)	Energy	170 TJ	63 MJ	0.69 MJ
	GHG	24,000 mt GGE	9,000 g GGE	98 g GGE
	SO2	55,000 kg	21,000 mg	230 mg
	CO	6,400 kg	2,400 mg	27 mg
	NOX	37,000 kg	14,000 mg	150 mg
	VOC	440 kg	170 mg	1.8 mg
	Pb	2.5 kg	0.94 mg	10 µg
	PM10	1,100 kg	430 mg	4,700 µg
V, Operation (Idling)	Energy	85 TJ	32 MJ	0.35 MJ
	GHG	12,000 mt GGE	4,600 g GGE	50 g GGE
	SO2	28,000 kg	11,000 mg	120 mg
	CO	3,300 kg	1,200 mg	14 mg
	NOX	19,000 kg	7,100 mg	77 mg
	VOC	220 kg	85 mg	0.93 mg
	Pb	1.3 kg	0.48 mg	5.3 µg
	PM10	580 kg	220 mg	2,400 µg
V, Operation (HVAC)	Energy	23 TJ	8.7 MJ	0.095 MJ
	GHG	3,300 mt GGE	1,200 g GGE	14 g GGE
	SO2	7,600 kg	2,900 mg	32 mg
	CO	890 kg	340 mg	3.7 mg
	NOX	5,100 kg	1,900 mg	21 mg
	VOC	61 kg	23 mg	0.25 mg
	Pb	0.35 kg	0.13 mg	1.4 µg
	PM10	160 kg	60 mg	660 µg
V, Maintenance	Energy	17 TJ	6.3 MJ	0.068 MJ
	GHG	750 mt GGE	290 g GGE	3.1 g GGE
	SO2	2,100 kg	790 mg	8.6 mg
	CO	1,900 kg	710 mg	7.7 mg
	NOX	1,800 kg	660 mg	7.3 mg
	VOC	2,700 kg	1,000 mg	11 mg
	Pb	7.3 kg	2.8 mg	30 µg
	PM10	520 kg	200 mg	2,200 µg
V, Maintenance (Cleaning)	Energy	0.30 TJ	0.11 MJ	0.0012 MJ
	GHG	18 mt GGE	6.7 g GGE	0.073 g GGE
	SO2	41 kg	15 mg	0.17 mg
	CO	4.8 kg	1.8 mg	0.020 mg
	NOX	27 kg	10 mg	0.11 mg
	VOC	0.33 kg	0.12 mg	0.0014 mg
	Pb	0.0019 kg	0.00070 mg	0.0077 µg
	PM10	0.85 kg	0.32 mg	3.5 µg
V, Maintenance (Flooring)	Energy	0.49 TJ	0.19 MJ	0.0020 MJ
	GHG	37 mt GGE	14 g GGE	0.15 g GGE
	SO2	76 kg	29 mg	0.32 mg
	CO	270 kg	100 mg	1.1 mg
	NOX	69 kg	26 mg	0.28 mg
	VOC	62 kg	24 mg	0.26 mg
	Pb	-	-	-
	PM10	12 kg	4.7 mg	51 µg
V, Insurance (Employees)	Energy	22 TJ	8.3 MJ	0.091 MJ
	GHG	1,800 mt GGE	680 g GGE	7.4 g GGE
	SO2	4,400 kg	1,700 mg	18 mg
	CO	20,000 kg	7,500 mg	82 mg
	NOX	5,000 kg	1,900 mg	21 mg
	VOC	3,700 kg	1,400 mg	15 mg
	Pb	-	-	-
	PM10	940 kg	350 mg	3,900 µg
V, Insurance (Vehicles)	Energy	1.2 TJ	0.47 MJ	0.0051 MJ
	GHG	100 mt GGE	38 g GGE	0.42 g GGE
	SO2	250 kg	94 mg	1.0 mg
	CO	1,100 kg	420 mg	4.6 mg
	NOX	280 kg	110 mg	1.2 mg
	VOC	210 kg	78 mg	0.86 mg
	Pb	-	-	-
	PM10	53 kg	20 mg	220 µg

Table 32 – Chicago Metro Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	75 TJ	29 MJ	0.31 MJ
	GHG	7,500 mt GGE	2,800 g GGE	31 g GGE
	SO2	23,000 kg	8,700 mg	95 mg
	CO	62,000 kg	23,000 mg	260 mg
	NOX	31,000 kg	12,000 mg	130 mg
	VOC	20,000 kg	7,500 mg	82 mg
	Pb	3.5 kg	1.3 mg	14 µg
	PM10	4,000 kg	1,500 mg	17,000 µg
I, Station Lighting	Energy	25 TJ	9.4 MJ	0.10 MJ
	GHG	3,500 mt GGE	1,300 g GGE	15 g GGE
	SO2	8,200 kg	3,100 mg	34 mg
	CO	960 kg	360 mg	4.0 mg
	NOX	5,500 kg	2,100 mg	23 mg
	VOC	66 kg	25 mg	0.27 mg
	Pb	0.37 kg	0.14 mg	1.5 µg
	PM10	170 kg	65 mg	710 µg
I, Station Escalators	Energy	2.8 TJ	1.1 MJ	0.012 MJ
	GHG	410 mt GGE	150 g GGE	1.7 g GGE
	SO2	940 kg	360 mg	3.9 mg
	CO	110 kg	42 mg	0.45 mg
	NOX	630 kg	240 mg	2.6 mg
	VOC	7.6 kg	2.9 mg	0.031 mg
	Pb	0.043 kg	0.016 mg	0.18 µg
	PM10	20 kg	7.4 mg	81 µg
I, Station Train Control	Energy	17 TJ	6.4 MJ	0.070 MJ
	GHG	2,400 mt GGE	920 g GGE	10 g GGE
	SO2	5,600 kg	2,100 mg	23 mg
	CO	650 kg	250 mg	2.7 mg
	NOX	3,800 kg	1,400 mg	16 mg
	VOC	45 kg	17 mg	0.19 mg
	Pb	0.25 kg	0.096 mg	1.1 µg
	PM10	120 kg	44 mg	480 µg
I, Station Parking Lighting	Energy	45 TJ	17 MJ	0.19 MJ
	GHG	6,400 mt GGE	2,400 g GGE	27 g GGE
	SO2	15,000 kg	5,600 mg	62 mg
	CO	1,700 kg	660 mg	7.2 mg
	NOX	10,000 kg	3,800 mg	41 mg
	VOC	120 kg	45 mg	0.50 mg
	Pb	0.68 kg	0.26 mg	2.8 µg
	PM10	310 kg	120 mg	1,300 µg
I, Station Miscellaneous	Energy	3.5 TJ	1.3 MJ	0.015 MJ
	GHG	500 mt GGE	190 g GGE	2.1 g GGE
	SO2	1,200 kg	440 mg	4.8 mg
	CO	140 kg	51 mg	0.56 mg
	NOX	780 kg	290 mg	3.2 mg
	VOC	9.4 kg	3.5 mg	0.039 mg
	Pb	0.053 kg	0.020 mg	0.22 µg
	PM10	24 kg	9.2 mg	100 µg
I, Station Maintenance	Energy	7.5 TJ	2.9 MJ	0.031 MJ
	GHG	750 mt GGE	280 g GGE	3.1 g GGE
	SO2	2,300 kg	870 mg	9.5 mg
	CO	6,200 kg	2,300 mg	26 mg
	NOX	3,100 kg	1,200 mg	13 mg
	VOC	2,000 kg	750 mg	8.2 mg
	Pb	0.35 kg	0.13 mg	1.4 µg
	PM10	400 kg	150 mg	1,700 µg
I, Station Cleaning	Energy	0.30 TJ	0.11 MJ	0.0012 MJ
	GHG	18 mt GGE	6.7 g GGE	0.073 g GGE
	SO2	41 kg	15 mg	0.17 mg
	CO	4.8 kg	1.8 mg	0.020 mg
	NOX	27 kg	10 mg	0.11 mg
	VOC	0.33 kg	0.12 mg	0.0014 mg
	Pb	0.0019 kg	0.00070 mg	0.0077 µg
	PM10	0.85 kg	0.32 mg	3.5 µg
I, Station Parking	Energy	3.0 TJ	1.1 MJ	0.013 MJ
	GHG	250 mt GGE	95 g GGE	1.0 g GGE
	SO2	490 kg	190 mg	2.0 mg
	CO	780 kg	300 mg	3.2 mg
	NOX	1,300 kg	480 mg	5.3 mg
	VOC	1,500 kg	570 mg	6.3 mg
	Pb	0.14 kg	0.054 mg	0.59 µg
	PM10	680 kg	260 mg	2,800 µg

(Table 32 continued on the following page…)

Table 32 – Chicago Metro Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	6.4 TJ	2.4 MJ	0.026 MJ
	GHG	580 mt GGE	220 g GGE	2.4 g GGE
	SO2	1,000 kg	390 mg	4.3 mg
	CO	5,400 kg	2,000 mg	22 mg
	NOX	970 kg	370 mg	4.0 mg
	VOC	580 kg	220 mg	2.4 mg
	Pb	2.9 kg	1.1 mg	12 µg
	PM10	530 kg	200 mg	2,200 µg
I, Track Maintenance	Energy	5.6 TJ	2.1 MJ	0.023 MJ
	GHG	230 mt GGE	88 g GGE	0.96 g GGE
	SO2	220 kg	82 mg	0.90 mg
	CO	110 kg	42 mg	0.46 mg
	NOX	380 kg	150 mg	1.6 mg
	VOC	76 kg	29 mg	0.31 mg
	Pb	0.26 kg	0.097 mg	1.1 µg
	PM10	66 kg	25 mg	270 µg
I, Insurance (Employees)	Energy	10 TJ	3.8 MJ	0.042 MJ
	GHG	820 mt GGE	310 g GGE	3.4 g GGE
	SO2	2,000 kg	760 mg	8.4 mg
	CO	9,100 kg	3,500 mg	38 mg
	NOX	2,300 kg	860 mg	9.4 mg
	VOC	1,700 kg	640 mg	7.0 mg
	Pb	-	-	-
	PM10	430 kg	160 mg	1,800 µg
I, Insurance (Facilities)	Energy	0.57 TJ	0.21 MJ	0.0023 MJ
	GHG	46 mt GGE	18 g GGE	0.19 g GGE
	SO2	110 kg	43 mg	0.47 mg
	CO	510 kg	190 mg	2.1 mg
	NOX	130 kg	48 mg	0.53 mg
	VOC	95 kg	36 mg	0.39 mg
	Pb	-	-	-
	PM10	24 kg	9.1 mg	100 µg
F, Supply Chain (Vehicles)	Energy	37 TJ	14 MJ	0.15 MJ
	GHG	710 mt GGE	270 g GGE	2.9 g GGE
	SO2	8,700 kg	3,300 mg	36 mg
	CO	680 kg	260 mg	2.8 mg
	NOX	2,500 kg	930 mg	10 mg
	VOC	93 kg	35 mg	0.38 mg
	Pb	0.020 kg	0.0075 mg	0.082 µg
	PM10	69 kg	26 mg	290 µg
F, T&D Losses (Vehicles)	Energy	29 TJ	11 MJ	0.12 MJ
	GHG	440 mt GGE	170 g GGE	1.8 g GGE
	SO2	1,000 kg	390 mg	4.2 mg
	CO	120 kg	45 mg	0.49 mg
	NOX	680 kg	260 mg	2.8 mg
	VOC	8.2 kg	3.1 mg	0.034 mg
	Pb	0.046 kg	0.018 mg	0.19 µg
	PM10	21 kg	8.1 mg	88 µg
F, Supply Chain (Infrastructure)	Energy	13 TJ	4.8 MJ	0.052 MJ
	GHG	240 mt GGE	92 g GGE	1.0 g GGE
	SO2	2,900 kg	1,100 mg	12 mg
	CO	230 kg	88 mg	0.96 mg
	NOX	840 kg	320 mg	3.5 mg
	VOC	32 kg	12 mg	0.13 mg
	Pb	0.0067 kg	0.0025 mg	0.028 µg
	PM10	23 kg	8.9 mg	97 µg
F, T&D Losses (Infrastructure)	Energy	9.9 TJ	3.7 MJ	0.041 MJ
	GHG	150 mt GGE	57 g GGE	0.62 g GGE
	SO2	350 kg	130 mg	1.4 mg
	CO	41 kg	15 mg	0.17 mg
	NOX	230 kg	88 mg	0.96 mg
	VOC	2.8 kg	1.1 mg	0.012 mg
	Pb	0.016 kg	0.0060 mg	0.065 µg
	PM10	7.3 kg	2.7 mg	30 µg

7 Supporting Data for Updated Conventional Gasoline Automobiles, Urban Diesel Buses, San Francisco Bay Area Rail, and Boston Rail Modes

In addition to the supplemental modes discussed, updated inventories for Chester (2009) are presented here. These inventories reflect several minor changes to the onroad and rail modes since August 2008. The major updates include:

- An increase in the average parking space size by 20% to capture the parking area increase needed to physically accommodate the growth of light duty trucks in the automobile fleet fraction.
- Adjustments to the U.S. vehicle fleet inventory which effects all inventory attributions.
- Adjustments to the parking garage construction environmental factors to include additional life-cycle components and not just direct construction operations.

The updated detailed inventories for each life-cycle component for each mode are found in the following subsections:

7.1 Conventional Gasoline Vehicle (Sedan)

Table 33 – Conventional Gasoline Vehicle (Sedan) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	100 GJ	550 kJ	350 kJ
	GHG	8.5 mt GGE	45 g GGE	29 g GGE
	SO_2	20 kg	110 mg	67 mg
	CO	110 kg	560 mg	350 mg
	NO_X	20 kg	110 mg	66 mg
	VOC	21 kg	110 mg	70 mg
	PM_{10}	5.7 kg	30 mg	19 mg
	Pb	27 g	140 µg	92 µg
V, Operation (Running)	Energy	890 GJ	4,800 kJ	3,000 kJ
	GHG	69 mt GGE	370 g GGE	230 g GGE
	SO_2	3.9 kg	21 mg	13 mg
	CO	2,100 kg	11,000 mg	6,900 mg
	NO_X	160 kg	850 mg	530 mg
	VOC	59 kg	310 mg	200 mg
	PM_{10}	20 kg	110 mg	68 mg
	Pb	-	-	-
V, Operation (Start)	CO	1,400 kg	7,300 mg	4,600 mg
	NO_X	32 kg	170 mg	110 mg
	VOC	66 kg	350 mg	220 mg
V, Operation (Tire)	PM_{10}	1.5 kg	8.0 mg	5.1 mg
V, Operation (Brake)	PM_{10}	2.3 kg	13 mg	7.9 mg
V, Automotive Repair	GHG	120 g GGE	640 µg GGE	400 µg GGE
V, Automotive Repair	VOC	2.8 kg	15 mg	9.3 mg
V, Evaporative Losses	VOC	94 kg	500 mg	320 mg
V, Tire Production	Energy	19 GJ	99 kJ	63 kJ
	GHG	1.3 mt GGE	7.2 g GGE	4.5 g GGE
	SO_2	2.4 kg	13 mg	8.2 mg
	CO	19 kg	100 mg	63 mg
	NO_X	2.5 kg	13 mg	8.4 mg
	VOC	3.2 kg	17 mg	11 mg
	PM_{10}	-	-	-
	Pb	1,400 g	7,500 µg	4,700 µg
V, Maintenance	Energy	40 GJ	210 kJ	140 kJ
	GHG	3.3 mt GGE	17 g GGE	11 g GGE
	SO_2	8.4 kg	45 mg	28 mg
	CO	33 kg	180 mg	110 mg
	NO_X	7.7 kg	41 mg	26 mg
	VOC	9.7 kg	52 mg	33 mg
	PM_{10}	-	-	-
	Pb	1,600 g	8,800 µg	5,600 µg
V, Fixed Costs / Insurance	Energy	13 GJ	69 kJ	44 kJ
	GHG	1.1 mt GGE	5.6 g GGE	3.6 g GGE
	SO_2	2.6 kg	14 mg	8.7 mg
	CO	12 kg	62 mg	39 mg
	NO_X	2.9 kg	16 mg	9.8 mg
	VOC	2.2 kg	12 mg	7.3 mg
	PM_{10}	0.55 kg	2.9 mg	1.9 mg
	Pb	-	-	-

Table 34 – Conventional Gasoline Vehicle (Sedan) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	160 GJ	860 kJ	550 kJ
	GHG	14 mt GGE	73 g GGE	46 g GGE
	SO_2	26 kg	140 mg	89 mg
	CO	42 kg	230 mg	140 mg
	NO_x	65 kg	350 mg	220 mg
	VOC	85 kg	450 mg	290 mg
	PM_{10}	37 kg	200 mg	120 mg
	Pb	7.9 g	42 µg	27 µg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	940 MJ	5.0 kJ	3.2 kJ
	GHG	70 kg GGE	370 mg GGE	240 mg GGE
	SO_2	140 mg	0.74 µg	0.47 µg
	CO	250 mg	1.4 µg	0.86 µg
	NO_x	93 mg	0.50 µg	0.31 µg
	VOC	100 mg	0.53 µg	0.34 µg
	PM_{10}	19 mg	0.10 µg	0.065 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	12 GJ	64 kJ	40 kJ
	GHG	2.5 mt GGE	13 g GGE	8.5 g GGE
	SO_2	13 kg	67 mg	43 mg
	CO	1.2 kg	6.5 mg	4.1 mg
	NO_x	4.2 kg	22 mg	14 mg
	VOC	0.11 kg	0.57 mg	0.36 mg
	PM_{10}	0.14 kg	0.74 mg	0.47 mg
	Pb	200 mg	1.0 µg	0.66 µg
I, Parking	Energy	15 GJ	79 kJ	50 kJ
	GHG	1.2 mt GGE	6.6 g GGE	4.2 g GGE
	SO_2	3.6 kg	19 mg	12 mg
	CO	5.2 kg	28 mg	18 mg
	NO_x	6.4 kg	34 mg	22 mg
	VOC	5.2 kg	27 mg	17 mg
	PM_{10}	2.7 kg	14 mg	9.0 mg
	Pb	700 mg	3.7 µg	2.4 µg
F, Refining & Distribution	Energy	130 GJ	680 kJ	430 kJ
	GHG	12 mt GGE	61 g GGE	39 g GGE
	SO_2	22 kg	120 mg	73 mg
	CO	32 kg	170 mg	110 mg
	NO_x	18 kg	95 mg	60 mg
	VOC	14 kg	74 mg	47 mg
	PM_{10}	2.9 kg	16 mg	9.9 mg
	Pb	-	-	-

7.2 Conventional Gasoline Vehicle (SUV)

Table 35 – Conventional Gasoline Vehicle (SUV) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	150 GJ	850 kJ	490 kJ
	GHG	12 mt GGE	71 g GGE	41 g GGE
	SO_2	28 kg	160 mg	94 mg
	CO	150 kg	870 mg	500 mg
	NO_X	28 kg	160 mg	94 mg
	VOC	29 kg	170 mg	98 mg
	PM_{10}	8.1 kg	47 mg	27 mg
	Pb	39 g	220 µg	130 µg
V, Operation (Running)	Energy	1,300 GJ	7,800 kJ	4,500 kJ
	GHG	82 mt GGE	480 g GGE	270 g GGE
	SO_2	4.6 kg	27 mg	15 mg
	CO	2,000 kg	12,000 mg	6,800 mg
	NO_X	180 kg	1,000 mg	600 mg
	VOC	69 kg	400 mg	230 mg
	PM_{10}	18 kg	110 mg	61 mg
	Pb	-	-	-
V, Operation (Start)	CO	1,600 kg	9,400 mg	5,400 mg
	NO_X	38 kg	220 mg	130 mg
	VOC	82 kg	470 mg	270 mg
V, Operation (Tire)	PM_{10}	1.4 kg	8.0 mg	4.6 mg
V, Operation (Brake)	PM_{10}	2.2 kg	13 mg	7.2 mg
V, Automotive Repair	GHG	97 g GGE	570 µg GGE	330 µg GGE
V, Automotive Repair	VOC	2.2 kg	13 mg	7.5 mg
V, Evaporative Losses	VOC	86 kg	500 mg	290 mg
V, Tire Production	Energy	17 GJ	99 kJ	57 kJ
	GHG	1.2 mt GGE	7.2 g GGE	4.1 g GGE
	SO_2	2.2 kg	13 mg	7.4 mg
	CO	17 kg	100 mg	57 mg
	NO_X	2.3 kg	13 mg	7.7 mg
	VOC	2.9 kg	17 mg	9.8 mg
	PM_{10}	-	-	-
	Pb	1,300 g	7,500 µg	4,300 µg
V, Maintenance	Energy	41 GJ	240 kJ	140 kJ
	GHG	3.3 mt GGE	19 g GGE	11 g GGE
	SO_2	8.6 kg	50 mg	29 mg
	CO	34 kg	200 mg	110 mg
	NO_X	7.9 kg	46 mg	26 mg
	VOC	10.0 kg	58 mg	33 mg
	PM_{10}	-	-	-
	Pb	1,700 g	9,800 µg	5,700 µg
V, Fixed Costs / Insurance	Energy	12 GJ	70 kJ	40 kJ
	GHG	0.99 mt GGE	5.7 g GGE	3.3 g GGE
	SO_2	2.4 kg	14 mg	8.1 mg
	CO	11 kg	63 mg	36 mg
	NO_X	2.7 kg	16 mg	9.1 mg
	VOC	2.0 kg	12 mg	6.8 mg
	PM_{10}	0.51 kg	3.0 mg	1.7 mg
	Pb	-	-	-

Table 36 – Conventional Gasoline Vehicle (SUV) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	150 GJ	860 kJ	500 kJ
	GHG	13 mt GGE	73 g GGE	42 g GGE
	SO_2	24 kg	140 mg	81 mg
	CO	39 kg	230 mg	130 mg
	NO_x	60 kg	350 mg	200 mg
	VOC	78 kg	450 mg	260 mg
	PM_{10}	34 kg	200 mg	110 mg
	Pb	7.3 g	42 µg	24 µg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	940 MJ	5.5 kJ	3.1 kJ
	GHG	70 kg GGE	410 mg GGE	230 mg GGE
	SO_2	140 mg	0.81 µg	0.47 µg
	CO	260 mg	1.5 µg	0.85 µg
	NO_x	94 mg	0.54 µg	0.31 µg
	VOC	100 mg	0.58 µg	0.33 µg
	PM_{10}	19 mg	0.11 µg	0.065 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	11 GJ	64 kJ	37 kJ
	GHG	2.3 mt GGE	13 g GGE	7.7 g GGE
	SO_2	12 kg	67 mg	39 mg
	CO	1.1 kg	6.5 mg	3.7 mg
	NO_x	3.8 kg	22 mg	13 mg
	VOC	0.099 kg	0.58 mg	0.33 mg
	PM_{10}	0.13 kg	0.74 mg	0.43 mg
	Pb	180 mg	1.1 µg	0.61 µg
I, Parking	Energy	15 GJ	87 kJ	50 kJ
	GHG	1.3 mt GGE	7.3 g GGE	4.2 g GGE
	SO_2	3.7 kg	21 mg	12 mg
	CO	5.3 kg	31 mg	18 mg
	NO_x	6.5 kg	38 mg	22 mg
	VOC	5.2 kg	30 mg	17 mg
	PM_{10}	2.7 kg	16 mg	9.0 mg
	Pb	710 mg	4.1 µg	2.4 µg
F, Refining & Distribution	Energy	190 GJ	1,100 kJ	640 kJ
	GHG	17 mt GGE	100 g GGE	58 g GGE
	SO_2	33 kg	190 mg	110 mg
	CO	48 kg	280 mg	160 mg
	NO_x	27 kg	160 mg	90 mg
	VOC	21 kg	120 mg	70 mg
	PM_{10}	4.4 kg	26 mg	15 mg
	Pb	-	-	-

7.3 Conventional Gasoline Vehicle (Pickup)

Table 37 – Conventional Gasoline Vehicle (Pickup) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	100 GJ	580 kJ	400 kJ
	GHG	8.3 mt GGE	48 g GGE	33 g GGE
	SO_2	19 kg	110 mg	77 mg
	CO	100 kg	590 mg	410 mg
	NO_X	19 kg	110 mg	76 mg
	VOC	20 kg	120 mg	80 mg
	PM_{10}	5.5 kg	32 mg	22 mg
	Pb	26 g	150 µg	110 µg
V, Operation (Running)	Energy	1,400 GJ	8,300 kJ	5,700 kJ
	GHG	110 mt GGE	620 g GGE	420 g GGE
	SO_2	6.0 kg	35 mg	24 mg
	CO	2,700 kg	16,000 mg	11,000 mg
	NO_X	240 kg	1,400 mg	950 mg
	VOC	110 kg	640 mg	440 mg
	PM_{10}	18 kg	100 mg	72 mg
	Pb	-	-	-
V, Operation (Start)	CO	2,000 kg	12,000 mg	8,000 mg
	NO_X	48 kg	280 mg	190 mg
	VOC	140 kg	820 mg	560 mg
V, Operation (Tire)	PM_{10}	1.4 kg	8.0 mg	5.5 mg
V, Operation (Brake)	PM_{10}	2.2 kg	13 mg	8.6 mg
V, Automotive Repair	GHG	98 g GGE	570 µg GGE	390 µg GGE
V, Automotive Repair	VOC	2.3 kg	13 mg	9.0 mg
V, Evaporative Losses	VOC	140 kg	800 mg	550 mg
V, Tire Production	Energy	17 GJ	99 kJ	68 kJ
	GHG	1.2 mt GGE	7.2 g GGE	4.9 g GGE
	SO_2	2.2 kg	13 mg	8.8 mg
	CO	17 kg	100 mg	68 mg
	NO_X	2.3 kg	13 mg	9.1 mg
	VOC	2.9 kg	17 mg	12 mg
	PM_{10}	-	-	-
	Pb	1,300 g	7,500 µg	5,100 µg
V, Maintenance	Energy	41 GJ	240 kJ	160 kJ
	GHG	3.3 mt GGE	19 g GGE	13 g GGE
	SO_2	8.6 kg	50 mg	34 mg
	CO	34 kg	200 mg	140 mg
	NO_X	7.9 kg	46 mg	31 mg
	VOC	10.0 kg	58 mg	40 mg
	PM_{10}	-	-	-
	Pb	1,700 g	9,800 µg	6,700 µg
V, Fixed Costs / Insurance	Energy	12 GJ	71 kJ	48 kJ
	GHG	0.99 mt GGE	5.8 g GGE	4.0 g GGE
	SO_2	2.4 kg	14 mg	9.7 mg
	CO	11 kg	64 mg	44 mg
	NO_X	2.7 kg	16 mg	11 mg
	VOC	2.0 kg	12 mg	8.1 mg
	PM_{10}	0.52 kg	3.0 mg	2.1 mg
	Pb	-	-	-

Table 38 – Conventional Gasoline Vehicle (Pickup) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	150 GJ	860 kJ	590 kJ
	GHG	13 mt GGE	73 g GGE	50 g GGE
	SO_2	24 kg	140 mg	96 mg
	CO	39 kg	230 mg	150 mg
	NO_x	60 kg	350 mg	240 mg
	VOC	78 kg	450 mg	310 mg
	PM_{10}	34 kg	200 mg	130 mg
	Pb	7.3 g	42 µg	29 µg
I, Roadway Maintenance	Energy	-	-	-
	GHG	-	-	-
	SO_2	-	-	-
	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
	PM_{10}	-	-	-
	Pb	-	-	-
I, Herbicides / Salting	Energy	940 MJ	5.5 kJ	3.8 kJ
	GHG	70 kg GGE	410 mg GGE	280 mg GGE
	SO_2	140 mg	0.81 µg	0.56 µg
	CO	260 mg	1.5 µg	1.0 µg
	NO_x	94 mg	0.54 µg	0.37 µg
	VOC	100 mg	0.58 µg	0.40 µg
	PM_{10}	19 mg	0.11 µg	0.077 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	11 GJ	64 kJ	44 kJ
	GHG	2.3 mt GGE	13 g GGE	9.2 g GGE
	SO_2	12 kg	67 mg	46 mg
	CO	1.1 kg	6.5 mg	4.4 mg
	NO_x	3.8 kg	22 mg	15 mg
	VOC	0.099 kg	0.58 mg	0.39 mg
	PM_{10}	0.13 kg	0.74 mg	0.51 mg
	Pb	180 mg	1.1 µg	0.72 µg
I, Parking	Energy	15 GJ	87 kJ	59 kJ
	GHG	1.3 mt GGE	7.3 g GGE	5.0 g GGE
	SO_2	3.7 kg	21 mg	15 mg
	CO	5.3 kg	31 mg	21 mg
	NO_x	6.5 kg	38 mg	26 mg
	VOC	5.2 kg	30 mg	21 mg
	PM_{10}	2.7 kg	16 mg	11 mg
	Pb	710 mg	4.1 µg	2.8 µg
F, Refining & Distribution	Energy	200 GJ	1,200 kJ	810 kJ
	GHG	19 mt GGE	110 g GGE	74 g GGE
	SO_2	35 kg	200 mg	140 mg
	CO	51 kg	300 mg	200 mg
	NO_x	29 kg	170 mg	110 mg
	VOC	22 kg	130 mg	88 mg
	PM_{10}	4.7 kg	27 mg	19 mg
	Pb	-	-	-

7.4 Urban Diesel Bus (Average)

Table 39 – Urban Diesel Bus (Average) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	1,700 GJ	3,400 kJ	330 kJ
	GHG	140 mt GGE	270 g GGE	26 g GGE
	SO_2	330 kg	670 mg	63 mg
	CO	1,600 kg	3,100 mg	300 mg
	NO_x	300 kg	610 mg	58 mg
	VOC	390 kg	780 mg	75 mg
	PM_{10}	87 kg	170 mg	17 mg
	Pb	400 g	810 µg	77 µg
V, Operation (Running)	Energy	16,000 GJ	32,000 kJ	3,100 kJ
	GHG	1,200 mt GGE	2,400 g GGE	230 g GGE
	SO_2	11 kg	22 mg	2.1 mg
	CO	2,200 kg	4,500 mg	420 mg
	NO_x	8,900 kg	18,000 mg	1,700 mg
	VOC	280 kg	550 mg	52 mg
	PM_{10}	340 kg	690 mg	66 mg
	Pb	-	-	-
V, Operation (Start)	CO	-	-	-
	NO_x	-	-	-
	VOC	-	-	-
V, Operation (Tire)	PM_{10}	6.0 kg	12 mg	1.1 mg
V, Operation (Brake)	PM_{10}	6.3 kg	13 mg	1.2 mg
V, Automotive Repair	GHG	130 g GGE	260 µg GGE	24 µg GGE
V, Automotive Repair	VOC	2.9 kg	5.9 mg	0.56 mg
V, Evaporative Losses	VOC	400 kg	800 mg	76 mg
V, Tire Production	Energy	560 GJ	1,100 kJ	110 kJ
	GHG	40 mt GGE	80 g GGE	7.6 g GGE
	SO_2	-	-	-
	CO	690 kg	1,400 mg	130 mg
	NO_x	1,000 kg	2,100 mg	200 mg
	VOC	71 kg	140 mg	14 mg
	PM_{10}	25 kg	50 mg	4.7 mg
	Pb	-	-	-
V, Maintenance	Energy	18 GJ	35 kJ	3.4 kJ
	GHG	1.3 mt GGE	2.5 g GGE	0.24 g GGE
	SO_2	2.3 kg	4.6 mg	0.44 mg
	CO	18 kg	36 mg	3.4 mg
	NO_x	2.4 kg	4.7 mg	0.45 mg
	VOC	3.0 kg	6.1 mg	0.58 mg
	PM_{10}	-	-	-
	Pb	1,300 g	2,700 µg	250 µg
V, Fixed Costs / Insurance	Energy	270 GJ	550 kJ	52 kJ
	GHG	22 mt GGE	45 g GGE	4.2 g GGE
	SO_2	57 kg	110 mg	11 mg
	CO	230 kg	460 mg	43 mg
	NO_x	52 kg	100 mg	10.0 mg
	VOC	66 kg	130 mg	13 mg
	PM_{10}	-	-	-
	Pb	11,000 g	23,000 µg	2,100 µg

Table 40 – Urban Diesel Bus (Average) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	400 GJ	790 kJ	75 kJ
	GHG	33 mt GGE	66 g GGE	6.3 g GGE
	SO_2	64 kg	130 mg	12 mg
	CO	100 kg	210 mg	20 mg
	NO_x	160 kg	320 mg	30 mg
	VOC	210 kg	410 mg	39 mg
	PM_{10}	89 kg	180 mg	17 mg
	Pb	19 g	39 µg	3.7 µg
I, Roadway Maintenance	Energy	460 GJ	930 kJ	88 kJ
	GHG	39 mt GGE	79 g GGE	7.5 g GGE
	SO_2	75 kg	150 mg	14 mg
	CO	120 kg	240 mg	23 mg
	NO_x	180 kg	360 mg	34 mg
	VOC	250 kg	510 mg	48 mg
	PM_{10}	110 kg	210 mg	20 mg
	Pb	23 g	46 µg	4.4 µg
I, Herbicides / Salting	Energy	910 MJ	1.8 kJ	0.17 kJ
	GHG	67 kg GGE	130 mg GGE	13 mg GGE
	SO_2	130 mg	0.27 µg	0.026 µg
	CO	250 mg	0.49 µg	0.047 µg
	NO_x	90 mg	0.18 µg	0.017 µg
	VOC	96 mg	0.19 µg	0.018 µg
	PM_{10}	19 mg	0.037 µg	0.0035 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	12 GJ	23 kJ	2.2 kJ
	GHG	2.4 mt GGE	4.9 g GGE	0.46 g GGE
	SO_2	12 kg	24 mg	2.3 mg
	CO	1.2 kg	2.3 mg	0.22 mg
	NO_x	4.0 kg	8.0 mg	0.77 mg
	VOC	0.10 kg	0.21 mg	0.020 mg
	PM_{10}	0.13 kg	0.27 mg	0.025 mg
	Pb	190 mg	0.38 µg	0.036 µg
I, Parking	Energy	2,100 GJ	4,200 kJ	400 kJ
	GHG	190 mt GGE	380 g GGE	36 g GGE
	SO_2	360 kg	720 mg	68 mg
	CO	530 kg	1,100 mg	100 mg
	NO_x	310 kg	620 mg	59 mg
	VOC	230 kg	460 mg	43 mg
	PM_{10}	51 kg	100 mg	9.7 mg
	Pb	-	-	-
F, Refining & Distribution	Energy	400 GJ	790 kJ	75 kJ
	GHG	33 mt GGE	66 g GGE	6.3 g GGE
	SO_2	64 kg	130 mg	12 mg
	CO	100 kg	210 mg	20 mg
	NO_x	160 kg	320 mg	30 mg
	VOC	210 kg	410 mg	39 mg
	PM_{10}	89 kg	180 mg	17 mg
	Pb	19 g	39 µg	3.7 µg

7.5 Urban Diesel Bus (Off-Peak)

Table 41 – Urban Diesel Bus (Off-Peak) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	1,700 GJ	3,400 kJ	680 kJ
	GHG	140 mt GGE	270 g GGE	54 g GGE
	SO_2	330 kg	670 mg	130 mg
	CO	1,600 kg	3,100 mg	620 mg
	NO_X	300 kg	610 mg	120 mg
	VOC	390 kg	780 mg	160 mg
	PM_{10}	87 kg	170 mg	35 mg
	Pb	400 g	810 µg	160 µg
V, Operation (Running)	Energy	16,000 GJ	32,000 kJ	6,400 kJ
	GHG	1,200 mt GGE	2,400 g GGE	470 g GGE
	SO_2	11 kg	22 mg	4.4 mg
	CO	2,200 kg	4,500 mg	890 mg
	NO_X	8,900 kg	18,000 mg	3,600 mg
	VOC	280 kg	550 mg	110 mg
	PM_{10}	340 kg	690 mg	140 mg
	Pb	-	-	-
V, Operation (Start)	CO	-	-	-
	NO_X	-	-	-
	VOC	-	-	-
V, Operation (Tire)	PM_{10}	6.0 kg	12 mg	2.4 mg
V, Operation (Brake)	PM_{10}	6.3 kg	13 mg	2.5 mg
V, Automotive Repair	GHG	130 g GGE	260 µg GGE	51 µg GGE
V, Automotive Repair	VOC	2.9 kg	5.9 mg	1.2 mg
V, Evaporative Losses	VOC	400 kg	800 mg	160 mg
V, Tire Production	Energy	560 GJ	1,100 kJ	220 kJ
	GHG	40 mt GGE	80 g GGE	16 g GGE
	SO_2	-	-	-
	CO	690 kg	1,400 mg	270 mg
	NO_X	1,000 kg	2,100 mg	420 mg
	VOC	71 kg	140 mg	28 mg
	PM_{10}	25 kg	50 mg	10.0 mg
	Pb	-	-	-
V, Maintenance	Energy	18 GJ	35 kJ	7.1 kJ
	GHG	1.3 mt GGE	2.5 g GGE	0.51 g GGE
	SO_2	2.3 kg	4.6 mg	0.92 mg
	CO	18 kg	36 mg	7.1 mg
	NO_X	2.4 kg	4.7 mg	0.95 mg
	VOC	3.0 kg	6.1 mg	1.2 mg
	PM_{10}	-	-	-
	Pb	1,300 g	2,700 µg	530 µg
V, Fixed Costs / Insurance	Energy	270 GJ	550 kJ	110 kJ
	GHG	22 mt GGE	45 g GGE	8.9 g GGE
	SO_2	57 kg	110 mg	23 mg
	CO	230 kg	460 mg	91 mg
	NO_X	52 kg	100 mg	21 mg
	VOC	66 kg	130 mg	27 mg
	PM_{10}	-	-	-
	Pb	11,000 g	23,000 µg	4,500 µg

Table 42 – Urban Diesel Bus (Off-Peak) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	400 GJ	790 kJ	160 kJ
	GHG	33 mt GGE	66 g GGE	13 g GGE
	SO_2	64 kg	130 mg	26 mg
	CO	100 kg	210 mg	41 mg
	NO_x	160 kg	320 mg	64 mg
	VOC	210 kg	410 mg	83 mg
	PM_{10}	89 kg	180 mg	36 mg
	Pb	19 g	39 µg	7.7 µg
I, Roadway Maintenance	Energy	460 GJ	930 kJ	190 kJ
	GHG	39 mt GGE	79 g GGE	16 g GGE
	SO_2	75 kg	150 mg	30 mg
	CO	120 kg	240 mg	49 mg
	NO_x	180 kg	360 mg	72 mg
	VOC	250 kg	510 mg	100 mg
	PM_{10}	110 kg	210 mg	42 mg
	Pb	23 g	46 µg	9.3 µg
I, Herbicides / Salting	Energy	910 MJ	1.8 kJ	0.36 kJ
	GHG	67 kg GGE	130 mg GGE	27 mg GGE
	SO_2	130 mg	0.27 µg	0.054 µg
	CO	250 mg	0.49 µg	0.099 µg
	NO_x	90 mg	0.18 µg	0.036 µg
	VOC	96 mg	0.19 µg	0.039 µg
	PM_{10}	19 mg	0.037 µg	0.0074 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	12 GJ	23 kJ	4.6 kJ
	GHG	2.4 mt GGE	4.9 g GGE	0.98 g GGE
	SO_2	12 kg	24 mg	4.9 mg
	CO	1.2 kg	2.3 mg	0.47 mg
	NO_x	4.0 kg	8.0 mg	1.6 mg
	VOC	0.10 kg	0.21 mg	0.042 mg
	PM_{10}	0.13 kg	0.27 mg	0.054 mg
	Pb	190 mg	0.38 µg	0.076 µg
I, Parking	Energy	2,100 GJ	4,200 kJ	840 kJ
	GHG	190 mt GGE	380 g GGE	77 g GGE
	SO_2	360 kg	720 mg	140 mg
	CO	530 kg	1,100 mg	210 mg
	NO_x	310 kg	620 mg	120 mg
	VOC	230 kg	460 mg	91 mg
	PM_{10}	51 kg	100 mg	20 mg
	Pb	-	-	-
F, Refining & Distribution	Energy	400 GJ	790 kJ	160 kJ
	GHG	33 mt GGE	66 g GGE	13 g GGE
	SO_2	64 kg	130 mg	26 mg
	CO	100 kg	210 mg	41 mg
	NO_x	160 kg	320 mg	64 mg
	VOC	210 kg	410 mg	83 mg
	PM_{10}	89 kg	180 mg	36 mg
	Pb	19 g	39 µg	7.7 µg

7.6 Urban Diesel Bus (Peak)

Table 43 – Urban Diesel Bus (Peak) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	1,700 GJ	3,400 kJ	85 kJ
	GHG	140 mt GGE	270 g GGE	6.8 g GGE
	SO_2	330 kg	670 mg	17 mg
	CO	1,600 kg	3,100 mg	78 mg
	NO_X	300 kg	610 mg	15 mg
	VOC	390 kg	780 mg	20 mg
	PM_{10}	87 kg	170 mg	4.4 mg
	Pb	400 g	810 µg	20 µg
V, Operation (Running)	Energy	16,000 GJ	32,000 kJ	800 kJ
	GHG	1,200 mt GGE	2,400 g GGE	59 g GGE
	SO_2	11 kg	22 mg	0.55 mg
	CO	2,200 kg	4,500 mg	110 mg
	NO_X	8,900 kg	18,000 mg	450 mg
	VOC	280 kg	550 mg	14 mg
	PM_{10}	340 kg	690 mg	17 mg
	Pb	-	-	-
V, Operation (Start)	CO	-	-	-
	NO_X	-	-	-
	VOC	-	-	-
V, Operation (Tire)	PM_{10}	6.0 kg	12 mg	0.30 mg
V, Operation (Brake)	PM_{10}	6.3 kg	13 mg	0.31 mg
V, Automotive Repair	GHG	130 g GGE	260 µg GGE	6.4 µg GGE
V, Automotive Repair	VOC	2.9 kg	5.9 mg	0.15 mg
V, Evaporative Losses	VOC	400 kg	800 mg	20 mg
V, Tire Production	Energy	560 GJ	1,100 kJ	28 kJ
	GHG	40 mt GGE	80 g GGE	2.0 g GGE
	SO_2	-	-	-
	CO	690 kg	1,400 mg	34 mg
	NO_X	1,000 kg	2,100 mg	52 mg
	VOC	71 kg	140 mg	3.6 mg
	PM_{10}	25 kg	50 mg	1.2 mg
	Pb	-	-	-
V, Maintenance	Energy	18 GJ	35 kJ	0.88 kJ
	GHG	1.3 mt GGE	2.5 g GGE	0.064 g GGE
	SO_2	2.3 kg	4.6 mg	0.11 mg
	CO	18 kg	36 mg	0.89 mg
	NO_X	2.4 kg	4.7 mg	0.12 mg
	VOC	3.0 kg	6.1 mg	0.15 mg
	PM_{10}	-	-	-
	Pb	1,300 g	2,700 µg	67 µg
V, Fixed Costs / Insurance	Energy	270 GJ	550 kJ	14 kJ
	GHG	22 mt GGE	45 g GGE	1.1 g GGE
	SO_2	57 kg	110 mg	2.9 mg
	CO	230 kg	460 mg	11 mg
	NO_X	52 kg	100 mg	2.6 mg
	VOC	66 kg	130 mg	3.3 mg
	PM_{10}	-	-	-
	Pb	11,000 g	23,000 µg	560 µg

Table 44 – Urban Diesel Bus (Peak) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Roadway Construction	Energy	400 GJ	790 kJ	20 kJ
	GHG	33 mt GGE	66 g GGE	1.7 g GGE
	SO_2	64 kg	130 mg	3.2 mg
	CO	100 kg	210 mg	5.2 mg
	NO_x	160 kg	320 mg	7.9 mg
	VOC	210 kg	410 mg	10 mg
	PM_{10}	89 kg	180 mg	4.5 mg
	Pb	19 g	39 µg	0.96 µg
I, Roadway Maintenance	Energy	460 GJ	930 kJ	23 kJ
	GHG	39 mt GGE	79 g GGE	2.0 g GGE
	SO_2	75 kg	150 mg	3.8 mg
	CO	120 kg	240 mg	6.1 mg
	NO_x	180 kg	360 mg	9.0 mg
	VOC	250 kg	510 mg	13 mg
	PM_{10}	110 kg	210 mg	5.3 mg
	Pb	23 g	46 µg	1.2 µg
I, Herbicides / Salting	Energy	910 MJ	1.8 kJ	0.045 kJ
	GHG	67 kg GGE	130 mg GGE	3.4 mg GGE
	SO_2	130 mg	0.27 µg	0.0067 µg
	CO	250 mg	0.49 µg	0.012 µg
	NO_x	90 mg	0.18 µg	0.0045 µg
	VOC	96 mg	0.19 µg	0.0048 µg
	PM_{10}	19 mg	0.037 µg	0.00093 µg
	Pb	-	-	-
I, Roadway Lighting	Energy	12 GJ	23 kJ	0.58 kJ
	GHG	2.4 mt GGE	4.9 g GGE	0.12 g GGE
	SO_2	12 kg	24 mg	0.61 mg
	CO	1.2 kg	2.3 mg	0.059 mg
	NO_x	4.0 kg	8.0 mg	0.20 mg
	VOC	0.10 kg	0.21 mg	0.0052 mg
	PM_{10}	0.13 kg	0.27 mg	0.0067 mg
	Pb	190 mg	0.38 µg	0.0095 µg
I, Parking	Energy	2,100 GJ	4,200 kJ	110 kJ
	GHG	190 mt GGE	380 g GGE	9.6 g GGE
	SO_2	360 kg	720 mg	18 mg
	CO	530 kg	1,100 mg	26 mg
	NO_x	310 kg	620 mg	16 mg
	VOC	230 kg	460 mg	11 mg
	PM_{10}	51 kg	100 mg	2.5 mg
	Pb	-	-	-
F, Refining & Distribution	Energy	400 GJ	790 kJ	20 kJ
	GHG	33 mt GGE	66 g GGE	1.7 g GGE
	SO_2	64 kg	130 mg	3.2 mg
	CO	100 kg	210 mg	5.2 mg
	NO_x	160 kg	320 mg	7.9 mg
	VOC	210 kg	410 mg	10 mg
	PM_{10}	89 kg	180 mg	4.5 mg
	Pb	19 g	39 µg	0.96 µg

7.7 Heavy Rail (San Francisco's Bay Area Rapid Transit)

Table 45 – Heavy Rail (San Francisco's BART) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	19 TJ	5.4 MJ	0.037 MJ
	GHG	1,100 mt GGE	330 g GGE	2.3 g GGE
	SO2	4,300 kg	1,200 mg	8.6 mg
	CO	1,300 kg	380 mg	2.6 mg
	NOX	2,300 kg	680 mg	4.7 mg
	VOC	590 kg	170 mg	1.2 mg
	Pb	4.9 kg	1.4 mg	9.8 µg
	PM10	1,200 kg	350 mg	2,400 µg
V, Operation (Active)	Energy	350 TJ	100 MJ	0.69 MJ
	GHG	19,000 mt GGE	5,600 g GGE	39 g GGE
	SO2	110,000 kg	32,000 mg	220 mg
	CO	11,000 kg	3,200 mg	22 mg
	NOX	6,300 kg	1,800 mg	13 mg
	VOC	2,900 kg	840 mg	5.8 mg
	Pb	0.070 kg	0.021 mg	0.14 µg
	PM10	1,200 kg	340 mg	2,400 µg
V, Operation (Idling)	Energy	180 TJ	51 MJ	0.35 MJ
	GHG	9,800 mt GGE	2,900 g GGE	20 g GGE
	SO2	55,000 kg	16,000 mg	110 mg
	CO	5,600 kg	1,600 mg	11 mg
	NOX	3,200 kg	930 mg	6.4 mg
	VOC	1,500 kg	430 mg	2.9 mg
	Pb	0.036 kg	0.010 mg	0.072 µg
	PM10	600 kg	170 mg	1,200 µg
V, Operation (HVAC)	Energy	48 TJ	14 MJ	0.096 MJ
	GHG	2,700 mt GGE	780 g GGE	5.4 g GGE
	SO2	15,000 kg	4,400 mg	30 mg
	CO	1,500 kg	440 mg	3.0 mg
	NOX	870 kg	250 mg	1.7 mg
	VOC	400 kg	120 mg	0.80 mg
	Pb	0.0098 kg	0.0028 mg	0.020 µg
	PM10	160 kg	48 mg	330 µg
V, Maintenance	Energy	15 TJ	4.4 MJ	0.030 MJ
	GHG	690 mt GGE	200 g GGE	1.4 g GGE
	SO2	1,900 kg	560 mg	3.8 mg
	CO	1,700 kg	500 mg	3.5 mg
	NOX	1,600 kg	470 mg	3.2 mg
	VOC	2,500 kg	730 mg	5.0 mg
	Pb	6.8 kg	2.0 mg	14 µg
	PM10	480 kg	140 mg	960 µg
V, Maintenance (Cleaning)	Energy	0.096 TJ	0.028 MJ	0.00019 MJ
	GHG	5.4 mt GGE	1.6 g GGE	0.011 g GGE
	SO2	0.00011 kg	0.000032 mg	0.00000022 mg
	CO	0.000011 kg	0.0000032 mg	0.000000022 mg
	NOX	0.0000063 kg	0.0000018 mg	0.000000013 mg
	VOC	0.0000029 kg	0.00000084 mg	0.0000000058 mg
	Pb	0.000000000071 kg	0.000000000021 mg	0.00000000014 µg
	PM10	0.0000012 kg	0.00000034 mg	0.0000024 µg
V, Maintenance (Flooring)	Energy	3.8 TJ	1.1 MJ	0.0076 MJ
	GHG	300 mt GGE	88 g GGE	0.60 g GGE
	SO2	550 kg	160 mg	1.1 mg
	CO	2,800 kg	830 mg	5.7 mg
	NOX	550 kg	160 mg	1.1 mg
	VOC	490 kg	140 mg	0.98 mg
	Pb	0.26 kg	0.077 mg	0.53 µg
	PM10	190 kg	55 mg	380 µg
V, Insurance (Employees)	Energy	0.47 TJ	0.14 MJ	0.00095 MJ
	GHG	39 mt GGE	11 g GGE	0.077 g GGE
	SO2	95 kg	28 mg	0.19 mg
	CO	430 kg	120 mg	0.86 mg
	NOX	110 kg	31 mg	0.21 mg
	VOC	79 kg	23 mg	0.16 mg
	Pb	-	-	-
	PM10	20 kg	5.9 mg	40 µg
V, Insurance (Vehicles)	Energy	1.0 TJ	0.31 MJ	0.0021 MJ
	GHG	86 mt GGE	25 g GGE	0.17 g GGE
	SO2	210 kg	61 mg	0.42 mg
	CO	950 kg	280 mg	1.9 mg
	NOX	240 kg	69 mg	0.47 mg
	VOC	180 kg	51 mg	0.35 mg
	Pb	-	-	-
	PM10	45 kg	13 mg	90 µg

Table 46 – Heavy Rail (San Francisco's BART) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	110 TJ	31 MJ	0.21 MJ
	GHG	11,000 mt GGE	3,100 g GGE	21 g GGE
	SO2	33,000 kg	9,500 mg	65 mg
	CO	88,000 kg	26,000 mg	180 mg
	NOX	44,000 kg	13,000 mg	89 mg
	VOC	28,000 kg	8,200 mg	56 mg
	Pb	5.0 kg	1.4 mg	9.9 µg
	PM10	5,700 kg	1,700 mg	11,000 µg
I, Station Lighting	Energy	3.7 TJ	1.1 MJ	0.0075 MJ
	GHG	210 mt GGE	61 g GGE	0.42 g GGE
	SO2	1,200 kg	340 mg	2.3 mg
	CO	120 kg	34 mg	0.24 mg
	NOX	68 kg	20 mg	0.14 mg
	VOC	31 kg	9.1 mg	0.062 mg
	Pb	0.00076 kg	0.00022 mg	0.0015 µg
	PM10	13 kg	3.7 mg	26 µg
I, Station Escalators	Energy	0.93 TJ	0.27 MJ	0.0019 MJ
	GHG	52 mt GGE	15 g GGE	0.10 g GGE
	SO2	290 kg	85 mg	0.58 mg
	CO	29 kg	8.6 mg	0.059 mg
	NOX	17 kg	4.9 mg	0.034 mg
	VOC	7.7 kg	2.3 mg	0.016 mg
	Pb	0.00019 kg	0.000055 mg	0.00038 µg
	PM10	3.2 kg	0.93 mg	6.4 µg
I, Station Train Control	Energy	1.6 TJ	0.47 MJ	0.0032 MJ
	GHG	89 mt GGE	26 g GGE	0.18 g GGE
	SO2	500 kg	150 mg	1.0 mg
	CO	51 kg	15 mg	0.10 mg
	NOX	29 kg	8.5 mg	0.058 mg
	VOC	13 kg	3.9 mg	0.027 mg
	Pb	0.00033 kg	0.000095 mg	0.00065 µg
	PM10	5.4 kg	1.6 mg	11 µg
I, Station Parking Lighting	Energy	22 TJ	6.4 MJ	0.044 MJ
	GHG	1,200 mt GGE	360 g GGE	2.5 g GGE
	SO2	6,900 kg	2,000 mg	14 mg
	CO	700 kg	200 mg	1.4 mg
	NOX	400 kg	120 mg	0.80 mg
	VOC	180 kg	54 mg	0.37 mg
	Pb	0.0045 kg	0.0013 mg	0.0090 µg
	PM10	75 kg	22 mg	150 µg
I, Station Miscellaneous	Energy	0.40 TJ	0.12 MJ	0.00079 MJ
	GHG	22 mt GGE	6.4 g GGE	0.044 g GGE
	SO2	120 kg	36 mg	0.25 mg
	CO	12 kg	3.6 mg	0.025 mg
	NOX	7.2 kg	2.1 mg	0.014 mg
	VOC	3.3 kg	0.96 mg	0.0066 mg
	Pb	0.000080 kg	0.000023 mg	0.00016 µg
	PM10	1.3 kg	0.39 mg	2.7 µg
I, Station Maintenance	Energy	7.2 TJ	2.1 MJ	0.014 MJ
	GHG	720 mt GGE	210 g GGE	1.4 g GGE
	SO2	2,200 kg	640 mg	4.4 mg
	CO	5,900 kg	1,700 mg	12 mg
	NOX	3,000 kg	870 mg	6.0 mg
	VOC	1,900 kg	550 mg	3.8 mg
	Pb	0.33 kg	0.097 mg	0.67 µg
	PM10	380 kg	110 mg	770 µg
I, Station Cleaning	Energy	0.096 TJ	0.028 MJ	0.00019 MJ
	GHG	5.4 mt GGE	1.6 g GGE	0.011 g GGE
	SO2	0.00011 kg	0.000032 mg	0.00000022 mg
	CO	0.000011 kg	0.0000032 mg	0.000000022 mg
	NOX	0.0000063 kg	0.0000018 mg	0.000000013 mg
	VOC	0.0000029 kg	0.00000084 mg	0.0000000058 mg
	Pb	0.000000000071 kg	0.000000000021 mg	0.00000000014 µg
	PM10	0.0000012 kg	0.00000034 mg	0.0000024 µg
I, Station Parking	Energy	45 TJ	13 MJ	0.089 MJ
	GHG	3,700 mt GGE	1,100 g GGE	7.4 g GGE
	SO2	7,300 kg	2,100 mg	15 mg
	CO	12,000 kg	3,400 mg	23 mg
	NOX	19,000 kg	5,500 mg	38 mg
	VOC	22,000 kg	6,500 mg	45 mg
	Pb	2.1 kg	0.62 mg	4.2 µg
	PM10	10,000 kg	2,900 mg	20,000 µg

(Table 46 continued on the following page…)

Table 46 – Heavy Rail (San Francisco's BART) Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	96 TJ	28 MJ	0.19 MJ
	GHG	9,000 mt GGE	2,600 g GGE	18 g GGE
	SO2	27,000 kg	7,800 mg	54 mg
	CO	75,000 kg	22,000 mg	150 mg
	NOX	33,000 kg	9,600 mg	66 mg
	VOC	24,000 kg	6,900 mg	47 mg
	Pb	7.9 kg	2.3 mg	16 µg
	PM10	4,900 kg	1,400 mg	9,700 µg
I, Track Maintenance	Energy	4.4 TJ	1.3 MJ	0.0088 MJ
	GHG	180 mt GGE	53 g GGE	0.37 g GGE
	SO2	170 kg	50 mg	0.34 mg
	CO	88 kg	26 mg	0.18 mg
	NOX	300 kg	88 mg	0.60 mg
	VOC	59 kg	17 mg	0.12 mg
	Pb	0.20 kg	0.059 mg	0.40 µg
	PM10	51 kg	15 mg	100 µg
I, Insurance (Employees)	Energy	1.3 TJ	0.38 MJ	0.0026 MJ
	GHG	110 mt GGE	31 g GGE	0.21 g GGE
	SO2	260 kg	77 mg	0.53 mg
	CO	1,200 kg	350 mg	2.4 mg
	NOX	300 kg	86 mg	0.59 mg
	VOC	220 kg	64 mg	0.44 mg
	Pb	-	-	-
	PM10	56 kg	16 mg	110 µg
I, Insurance (Facilities)	Energy	7.9 TJ	2.3 MJ	0.016 MJ
	GHG	640 mt GGE	190 g GGE	1.3 g GGE
	SO2	1,600 kg	460 mg	3.2 mg
	CO	7,100 kg	2,100 mg	14 mg
	NOX	1,800 kg	520 mg	3.6 mg
	VOC	1,300 kg	390 mg	2.6 mg
	Pb	-	-	-
	PM10	340 kg	98 mg	670 µg
F, Supply Chain (Vehicles)	Energy	82 TJ	24 MJ	0.16 MJ
	GHG	1,100 mt GGE	320 g GGE	2.2 g GGE
	SO2	25,000 kg	7,400 mg	51 mg
	CO	1,800 kg	540 mg	3.7 mg
	NOX	2,300 kg	670 mg	4.6 mg
	VOC	160 kg	48 mg	0.33 mg
	Pb	0.011 kg	0.0031 mg	0.021 µg
	PM10	87 kg	25 mg	170 µg
F, T&D Losses (Vehicles)	Energy	52 TJ	15 MJ	0.10 MJ
	GHG	310 mt GGE	90 g GGE	0.62 g GGE
	SO2	1,700 kg	510 mg	3.5 mg
	CO	180 kg	51 mg	0.35 mg
	NOX	100 kg	29 mg	0.20 mg
	VOC	46 kg	13 mg	0.092 mg
	Pb	0.0011 kg	0.00033 mg	0.0023 µg
	PM10	19 kg	5.5 mg	38 µg
F, Supply Chain (Infrastructure)	Energy	4.1 TJ	1.2 MJ	0.0083 MJ
	GHG	55 mt GGE	16 g GGE	0.11 g GGE
	SO2	1,300 kg	370 mg	2.6 mg
	CO	93 kg	27 mg	0.19 mg
	NOX	120 kg	34 mg	0.23 mg
	VOC	8.2 kg	2.4 mg	0.016 mg
	Pb	0.00054 kg	0.00016 mg	0.0011 µg
	PM10	4.4 kg	1.3 mg	8.7 µg
F, T&D Losses (Infrastructure)	Energy	2.6 TJ	0.77 MJ	0.0053 MJ
	GHG	16 mt GGE	4.6 g GGE	0.031 g GGE
	SO2	88 kg	26 mg	0.18 mg
	CO	8.8 kg	2.6 mg	0.018 mg
	NOX	5.1 kg	1.5 mg	0.010 mg
	VOC	2.3 kg	0.68 mg	0.0047 mg
	Pb	0.000057 kg	0.000017 mg	0.00011 µg
	PM10	0.95 kg	0.28 mg	1.9 µg

7.8 Heavy Rail (San Francisco Bay Area Caltrain)

Table 47 – Heavy Rail (San Francisco Bay Area Caltrain) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	30 TJ	24 MJ	0.16 MJ
	GHG	1,800 mt GGE	1,500 g GGE	9.6 g GGE
	SO2	6,900 kg	5,600 mg	36 mg
	CO	2,100 kg	1,700 mg	11 mg
	NOX	3,800 kg	3,100 mg	20 mg
	VOC	950 kg	770 mg	5.0 mg
	Pb	7.9 kg	6.4 mg	42 µg
	PM10	1,900 kg	1,600 mg	10,000 µg
V, Operation (Active)	Energy	170 TJ	140 MJ	0.90 MJ
	GHG	12,000 mt GGE	9,600 g GGE	62 g GGE
	SO2	52 kg	42 mg	0.27 mg
	CO	12,000 kg	9,300 mg	60 mg
	NOX	220,000 kg	180,000 mg	1,200 mg
	VOC	7,000 kg	5,600 mg	36 mg
	Pb	-	-	-
	PM10	6,000 kg	4,800 mg	31,000 µg
V, Operation (Idling)	Energy	23 TJ	19 MJ	0.12 MJ
	GHG	1,600 mt GGE	1,300 g GGE	8.4 g GGE
	SO2	7.0 kg	5.7 mg	0.037 mg
	CO	3,700 kg	3,000 mg	19 mg
	NOX	37,000 kg	30,000 mg	200 mg
	VOC	4,000 kg	3,200 mg	21 mg
	Pb	-	-	-
	PM10	1,100 kg	850 mg	5,500 µg
V, Operation (HVAC)	Energy	9.2 TJ	7.4 MJ	0.048 MJ
	GHG	630 mt GGE	510 g GGE	3.3 g GGE
	SO2	2.8 kg	2.3 mg	0.015 mg
	CO	610 kg	500 mg	3.2 mg
	NOX	12,000 kg	9,600 mg	62 mg
	VOC	370 kg	300 mg	1.9 mg
	Pb	-	-	-
	PM10	320 kg	260 mg	1,700 µg
V, Maintenance	Energy	25 TJ	20 MJ	0.13 MJ
	GHG	1,100 mt GGE	910 g GGE	5.9 g GGE
	SO2	3,100 kg	2,500 mg	16 mg
	CO	2,800 kg	2,300 mg	15 mg
	NOX	2,600 kg	2,100 mg	14 mg
	VOC	4,100 kg	3,300 mg	21 mg
	Pb	11 kg	8.9 mg	57 µg
	PM10	780 kg	630 mg	4,100 µg
V, Maintenance (Cleaning)	Energy	0.060 TJ	0.049 MJ	0.00032 MJ
	GHG	4.4 mt GGE	3.6 g GGE	0.023 g GGE
	SO2	24 kg	19 mg	0.12 mg
	CO	2.3 kg	1.8 mg	0.012 mg
	NOX	1.7 kg	1.4 mg	0.0089 mg
	VOC	0.51 kg	0.41 mg	0.0027 mg
	Pb	0.000031 kg	0.000025 mg	0.00016 µg
	PM10	0.26 kg	0.21 mg	1.3 µg
V, Maintenance (Flooring)	Energy	2.4 TJ	1.9 MJ	0.012 MJ
	GHG	190 mt GGE	150 g GGE	0.98 g GGE
	SO2	340 kg	280 mg	1.8 mg
	CO	1,800 kg	1,400 mg	9.3 mg
	NOX	340 kg	280 mg	1.8 mg
	VOC	310 kg	250 mg	1.6 mg
	Pb	0.16 kg	0.13 mg	0.86 µg
	PM10	120 kg	96 mg	620 µg
V, Insurance (Employees)	Energy	0.43 TJ	0.35 MJ	0.0023 MJ
	GHG	36 mt GGE	29 g GGE	0.19 g GGE
	SO2	87 kg	71 mg	0.46 mg
	CO	390 kg	320 mg	2.1 mg
	NOX	98 kg	80 mg	0.51 mg
	VOC	73 kg	59 mg	0.38 mg
	Pb	-	-	-
	PM10	19 kg	15 mg	97 µg
V, Insurance (Vehicles)	Energy	0.95 TJ	0.77 MJ	0.0050 MJ
	GHG	78 mt GGE	63 g GGE	0.41 g GGE
	SO2	190 kg	150 mg	1.00 mg
	CO	860 kg	700 mg	4.5 mg
	NOX	210 kg	170 mg	1.1 mg
	VOC	160 kg	130 mg	0.83 mg
	Pb	-	-	-
	PM10	41 kg	33 mg	210 µg

Table 48 – Heavy Rail (San Francisco Bay Area Caltrain) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	5.2 TJ	4.2 MJ	0.027 MJ
	GHG	510 mt GGE	410 g GGE	2.7 g GGE
	SO2	1,600 kg	1,300 mg	8.2 mg
	CO	4,200 kg	3,400 mg	22 mg
	NOX	2,100 kg	1,700 mg	11 mg
	VOC	1,400 kg	1,100 mg	7.1 mg
	Pb	0.24 kg	0.19 mg	1.3 µg
	PM10	270 kg	220 mg	1,400 µg
I, Station Lighting	Energy	14 TJ	11 MJ	0.071 MJ
	GHG	760 mt GGE	620 g GGE	4.0 g GGE
	SO2	4,300 kg	3,400 mg	22 mg
	CO	430 kg	350 mg	2.3 mg
	NOX	250 kg	200 mg	1.3 mg
	VOC	110 kg	92 mg	0.59 mg
	Pb	0.0028 kg	0.0022 mg	0.014 µg
	PM10	46 kg	38 mg	240 µg
I, Station Escalators	Energy	0.26 TJ	0.21 MJ	0.0014 MJ
	GHG	15 mt GGE	12 g GGE	0.077 g GGE
	SO2	82 kg	66 mg	0.43 mg
	CO	8.3 kg	6.7 mg	0.043 mg
	NOX	4.8 kg	3.9 mg	0.025 mg
	VOC	2.2 kg	1.8 mg	0.011 mg
	Pb	0.000053 kg	0.000043 mg	0.00028 µg
	PM10	0.89 kg	0.72 mg	4.7 µg
I, Station Train Control	Energy	25 TJ	20 MJ	0.13 MJ
	GHG	1,400 mt GGE	1,100 g GGE	7.3 g GGE
	SO2	7,800 kg	6,300 mg	41 mg
	CO	790 kg	640 mg	4.1 mg
	NOX	450 kg	370 mg	2.4 mg
	VOC	210 kg	170 mg	1.1 mg
	Pb	0.0051 kg	0.0041 mg	0.027 µg
	PM10	85 kg	69 mg	450 µg
I, Station Parking Lighting	Energy	8.4 TJ	6.8 MJ	0.044 MJ
	GHG	470 mt GGE	380 g GGE	2.5 g GGE
	SO2	2,600 kg	2,100 mg	14 mg
	CO	270 kg	210 mg	1.4 mg
	NOX	150 kg	120 mg	0.80 mg
	VOC	70 kg	57 mg	0.37 mg
	Pb	0.0017 kg	0.0014 mg	0.0089 µg
	PM10	29 kg	23 mg	150 µg
I, Station Miscellaneous	Energy	3.1 TJ	2.5 MJ	0.016 MJ
	GHG	180 mt GGE	140 g GGE	0.92 g GGE
	SO2	980 kg	800 mg	5.1 mg
	CO	99 kg	80 mg	0.52 mg
	NOX	57 kg	46 mg	0.30 mg
	VOC	26 kg	21 mg	0.14 mg
	Pb	0.00064 kg	0.00052 mg	0.0033 µg
	PM10	11 kg	8.7 mg	56 µg
I, Station Maintenance	Energy	0.31 TJ	0.25 MJ	0.0016 MJ
	GHG	31 mt GGE	25 g GGE	0.16 g GGE
	SO2	94 kg	76 mg	0.49 mg
	CO	250 kg	210 mg	1.3 mg
	NOX	130 kg	100 mg	0.67 mg
	VOC	81 kg	66 mg	0.43 mg
	Pb	0.014 kg	0.012 mg	0.075 µg
	PM10	16 kg	13 mg	86 µg
I, Station Cleaning	Energy	0.060 TJ	0.049 MJ	0.00032 MJ
	GHG	4.4 mt GGE	3.6 g GGE	0.023 g GGE
	SO2	24 kg	19 mg	0.12 mg
	CO	2.3 kg	1.8 mg	0.012 mg
	NOX	1.7 kg	1.4 mg	0.0089 mg
	VOC	0.51 kg	0.41 mg	0.0027 mg
	Pb	0.000031 kg	0.000025 mg	0.00016 µg
	PM10	0.26 kg	0.21 mg	1.3 µg
I, Station Parking	Energy	17 TJ	14 MJ	0.088 MJ
	GHG	1,400 mt GGE	1,100 g GGE	7.3 g GGE
	SO2	2,700 kg	2,200 mg	14 mg
	CO	4,400 kg	3,500 mg	23 mg
	NOX	7,100 kg	5,700 mg	37 mg
	VOC	8,400 kg	6,800 mg	44 mg
	Pb	0.80 kg	0.65 mg	4.2 µg
	PM10	3,800 kg	3,000 mg	20,000 µg

(Table 48 continued on the following page…)

Table 48 – Heavy Rail (San Francisco Bay Area Caltrain) Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	47 TJ	38 MJ	0.24 MJ
	GHG	4,300 mt GGE	3,500 g GGE	22 g GGE
	SO2	11,000 kg	8,500 mg	55 mg
	CO	37,000 kg	30,000 mg	190 mg
	NOX	12,000 kg	9,500 mg	62 mg
	VOC	8,000 kg	6,400 mg	42 mg
	Pb	12 kg	9.5 mg	61 µg
	PM10	3,000 kg	2,400 mg	16,000 µg
I, Track Maintenance	Energy	9.8 TJ	7.9 MJ	0.051 MJ
	GHG	410 mt GGE	330 g GGE	2.1 g GGE
	SO2	380 kg	310 mg	2.0 mg
	CO	200 kg	160 mg	1.0 mg
	NOX	670 kg	540 mg	3.5 mg
	VOC	130 kg	110 mg	0.69 mg
	Pb	0.45 kg	0.36 mg	2.3 µg
	PM10	110 kg	93 mg	600 µg
I, Insurance (Employees)	Energy	3.1 TJ	2.5 MJ	0.016 MJ
	GHG	250 mt GGE	200 g GGE	1.3 g GGE
	SO2	620 kg	500 mg	3.2 mg
	CO	2,800 kg	2,300 mg	15 mg
	NOX	690 kg	560 mg	3.6 mg
	VOC	520 kg	420 mg	2.7 mg
	Pb	-	-	-
	PM10	130 kg	110 mg	690 µg
I, Insurance (Facilities)	Energy	1.7 TJ	1.4 MJ	0.0090 MJ
	GHG	140 mt GGE	110 g GGE	0.74 g GGE
	SO2	350 kg	280 mg	1.8 mg
	CO	1,600 kg	1,300 mg	8.2 mg
	NOX	390 kg	320 mg	2.0 mg
	VOC	290 kg	230 mg	1.5 mg
	Pb	-	-	-
	PM10	73 kg	59 mg	380 µg
F, Supply Chain (Vehicles)	Energy	27 TJ	22 MJ	0.14 MJ
	GHG	2,400 mt GGE	2,000 g GGE	13 g GGE
	SO2	4,600 kg	3,700 mg	24 mg
	CO	6,700 kg	5,400 mg	35 mg
	NOX	4,000 kg	3,200 mg	21 mg
	VOC	2,900 kg	2,400 mg	15 mg
	Pb	-	-	-
	PM10	650 kg	520 mg	3,400 µg
F, T&D Losses (Vehicles)	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
F, Supply Chain (Infrastructure)	Energy	7.3 TJ	5.9 MJ	0.038 MJ
	GHG	97 mt GGE	79 g GGE	0.51 g GGE
	SO2	2,200 kg	1,800 mg	12 mg
	CO	160 kg	130 mg	0.85 mg
	NOX	200 kg	170 mg	1.1 mg
	VOC	14 kg	12 mg	0.076 mg
	Pb	0.00094 kg	0.00076 mg	0.0049 µg
	PM10	7.7 kg	6.2 mg	40 µg
F, T&D Losses (Infrastructure)	Energy	4.6 TJ	3.7 MJ	0.024 MJ
	GHG	27 mt GGE	22 g GGE	0.14 g GGE
	SO2	150 kg	120 mg	0.80 mg
	CO	16 kg	13 mg	0.081 mg
	NOX	8.9 kg	7.2 mg	0.047 mg
	VOC	4.1 kg	3.3 mg	0.021 mg
	Pb	0.000100 kg	0.000081 mg	0.00052 µg
	PM10	1.7 kg	1.4 mg	8.8 µg

7.9 Light Rail (San Francisco's Muni Metro)

Table 49 – Light Rail (San Francisco's Muni Metro) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	1.4 TJ	0.83 MJ	0.038 MJ
	GHG	71 mt GGE	42 g GGE	1.9 g GGE
	SO2	360 kg	210 mg	9.6 mg
	CO	580 kg	340 mg	15 mg
	NOX	210 kg	120 mg	5.5 mg
	VOC	53 kg	31 mg	1.4 mg
	Pb	1.4 kg	0.83 mg	38 µg
	PM10	140 kg	83 mg	3,800 µg
V, Operation (Active)	Energy	28 TJ	16 MJ	0.73 MJ
	GHG	1,500 mt GGE	890 g GGE	41 g GGE
	SO2	8,600 kg	5,000 mg	230 mg
	CO	870 kg	510 mg	23 mg
	NOX	500 kg	290 mg	13 mg
	VOC	230 kg	130 mg	6.1 mg
	Pb	0.0056 kg	0.0033 mg	0.15 µg
	PM10	94 kg	54 mg	2,500 µg
V, Operation (Idling)	Energy	14 TJ	8.2 MJ	0.37 MJ
	GHG	780 mt GGE	460 g GGE	21 g GGE
	SO2	4,400 kg	2,500 mg	120 mg
	CO	440 kg	260 mg	12 mg
	NOX	250 kg	150 mg	6.8 mg
	VOC	120 kg	68 mg	3.1 mg
	Pb	0.0029 kg	0.0017 mg	0.076 µg
	PM10	48 kg	28 mg	1,300 µg
V, Operation (HVAC)	Energy	4.8 TJ	2.8 MJ	0.13 MJ
	GHG	270 mt GGE	160 g GGE	7.1 g GGE
	SO2	1,500 kg	870 mg	40 mg
	CO	150 kg	88 mg	4.0 mg
	NOX	87 kg	51 mg	2.3 mg
	VOC	40 kg	23 mg	1.1 mg
	Pb	0.00098 kg	0.00057 mg	0.026 µg
	PM10	16 kg	9.5 mg	430 µg
V, Maintenance	Energy	0.28 TJ	0.16 MJ	0.0075 MJ
	GHG	14 mt GGE	7.9 g GGE	0.36 g GGE
	SO2	36 kg	21 mg	0.97 mg
	CO	50 kg	29 mg	1.3 mg
	NOX	43 kg	25 mg	1.1 mg
	VOC	28 kg	16 mg	0.74 mg
	Pb	0.29 kg	0.17 mg	7.6 µg
	PM10	12 kg	6.9 mg	310 µg
V, Maintenance (Cleaning)	Energy	0.027 TJ	0.015 MJ	0.00070 MJ
	GHG	0.62 mt GGE	0.36 g GGE	0.016 g GGE
	SO2	0.000012 kg	0.0000072 mg	0.00000033 mg
	CO	0.0000013 kg	0.00000073 mg	0.000000033 mg
	NOX	0.00000072 kg	0.00000042 mg	0.000000019 mg
	VOC	0.00000033 kg	0.00000019 mg	0.0000000088 mg
	Pb	0.0000000000081 kg	0.0000000000047 mg	0.00000000022 µg
	PM10	0.00000014 kg	0.000000079 mg	0.0000036 µg
V, Maintenance (Flooring)	Energy	0.044 TJ	0.026 MJ	0.0012 MJ
	GHG	3.3 mt GGE	1.9 g GGE	0.089 g GGE
	SO2	6.8 kg	4.0 mg	0.18 mg
	CO	24 kg	14 mg	0.65 mg
	NOX	6.2 kg	3.6 mg	0.16 mg
	VOC	5.6 kg	3.3 mg	0.15 mg
	Pb	-	-	-
	PM10	1.1 kg	0.65 mg	30 µg
V, Insurance (Employees)	Energy	0.71 TJ	0.41 MJ	0.019 MJ
	GHG	58 mt GGE	34 g GGE	1.6 g GGE
	SO2	140 kg	83 mg	3.8 mg
	CO	650 kg	380 mg	17 mg
	NOX	160 kg	94 mg	4.3 mg
	VOC	120 kg	70 mg	3.2 mg
	Pb	-	-	-
	PM10	31 kg	18 mg	810 µg
V, Insurance (Vehicles)	Energy	0.88 TJ	0.51 MJ	0.023 MJ
	GHG	72 mt GGE	42 g GGE	1.9 g GGE
	SO2	180 kg	100 mg	4.7 mg
	CO	800 kg	470 mg	21 mg
	NOX	200 kg	120 mg	5.3 mg
	VOC	150 kg	86 mg	3.9 mg
	Pb	-	-	-
	PM10	38 kg	22 mg	1,000 µg

Table 50 – Light Rail (San Francisco's Muni Metro) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	12 TJ	6.7 MJ	0.31 MJ
	GHG	1,200 mt GGE	670 g GGE	31 g GGE
	SO2	3,500 kg	2,000 mg	93 mg
	CO	9,500 kg	5,500 mg	250 mg
	NOX	4,800 kg	2,800 mg	130 mg
	VOC	3,000 kg	1,800 mg	81 mg
	Pb	0.54 kg	0.31 mg	14 µg
	PM10	620 kg	360 mg	16,000 µg
I, Station Lighting	Energy	8.0 TJ	4.6 MJ	0.21 MJ
	GHG	450 mt GGE	260 g GGE	12 g GGE
	SO2	2,500 kg	1,500 mg	66 mg
	CO	250 kg	150 mg	6.7 mg
	NOX	140 kg	84 mg	3.8 mg
	VOC	66 kg	39 mg	1.8 mg
	Pb	0.0016 kg	0.00094 mg	0.043 µg
	PM10	27 kg	16 mg	720 µg
I, Station Escalators	Energy	0.82 TJ	0.47 MJ	0.022 MJ
	GHG	46 mt GGE	26 g GGE	1.2 g GGE
	SO2	260 kg	150 mg	6.8 mg
	CO	26 kg	15 mg	0.68 mg
	NOX	15 kg	8.6 mg	0.39 mg
	VOC	6.8 kg	3.9 mg	0.18 mg
	Pb	0.00017 kg	0.000096 mg	0.0044 µg
	PM10	2.8 kg	1.6 mg	74 µg
I, Station Train Control	Energy	4.9 TJ	2.9 MJ	0.13 MJ
	GHG	280 mt GGE	160 g GGE	7.3 g GGE
	SO2	1,500 kg	900 mg	41 mg
	CO	160 kg	90 mg	4.1 mg
	NOX	90 kg	52 mg	2.4 mg
	VOC	41 kg	24 mg	1.1 mg
	Pb	0.0010 kg	0.00058 mg	0.027 µg
	PM10	17 kg	9.8 mg	450 µg
I, Station Parking Lighting	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
I, Station Miscellaneous	Energy	6.7 TJ	3.9 MJ	0.18 MJ
	GHG	380 mt GGE	220 g GGE	10.0 g GGE
	SO2	2,100 kg	1,200 mg	56 mg
	CO	210 kg	120 mg	5.6 mg
	NOX	120 kg	71 mg	3.2 mg
	VOC	56 kg	33 mg	1.5 mg
	Pb	0.0014 kg	0.00080 mg	0.036 µg
	PM10	23 kg	13 mg	610 µg
I, Station Maintenance	Energy	0.58 TJ	0.34 MJ	0.016 MJ
	GHG	58 mt GGE	34 g GGE	1.5 g GGE
	SO2	180 kg	100 mg	4.7 mg
	CO	480 kg	280 mg	13 mg
	NOX	240 kg	140 mg	6.4 mg
	VOC	150 kg	89 mg	4.1 mg
	Pb	0.027 kg	0.016 mg	0.72 µg
	PM10	31 kg	18 mg	820 µg
I, Station Cleaning	Energy	0.027 TJ	0.015 MJ	0.00070 MJ
	GHG	0.62 mt GGE	0.36 g GGE	0.016 g GGE
	SO2	0.000012 kg	0.0000072 mg	0.00000033 mg
	CO	0.0000013 kg	0.00000073 mg	0.000000033 mg
	NOX	0.00000072 kg	0.00000042 mg	0.000000019 mg
	VOC	0.00000033 kg	0.00000019 mg	0.0000000088 mg
	Pb	0.0000000000081 kg	0.0000000000047 mg	0.00000000022 µg
	PM10	0.00000014 kg	0.000000079 mg	0.0000036 µg
I, Station Parking	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-

(Table 50 continued on the following page…)

Table 50 – Light Rail (San Francisco's Muni Metro) Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	6.3 TJ	3.7 MJ	0.17 MJ
	GHG	570 mt GGE	330 g GGE	15 g GGE
	SO2	1,000 kg	610 mg	28 mg
	CO	5,500 kg	3,200 mg	150 mg
	NOX	930 kg	540 mg	25 mg
	VOC	580 kg	340 mg	15 mg
	Pb	2.9 kg	1.7 mg	76 µg
	PM10	550 kg	320 mg	14,000 µg
I, Track Maintenance	Energy	2.4 TJ	1.4 MJ	0.063 MJ
	GHG	170 mt GGE	100 g GGE	4.6 g GGE
	SO2	120 kg	67 mg	3.1 mg
	CO	390 kg	230 mg	10 mg
	NOX	810 kg	470 mg	21 mg
	VOC	84 kg	49 mg	2.2 mg
	Pb	-	-	-
	PM10	84 kg	49 mg	2,200 µg
I, Insurance (Employees)	Energy	1.7 TJ	0.99 MJ	0.045 MJ
	GHG	140 mt GGE	81 g GGE	3.7 g GGE
	SO2	340 kg	200 mg	9.1 mg
	CO	1,600 kg	900 mg	41 mg
	NOX	390 kg	230 mg	10 mg
	VOC	290 kg	170 mg	7.6 mg
	Pb	-	-	-
	PM10	73 kg	42 mg	1,900 µg
I, Insurance (Facilities)	Energy	3.2 TJ	1.8 MJ	0.084 MJ
	GHG	260 mt GGE	150 g GGE	6.9 g GGE
	SO2	640 kg	370 mg	17 mg
	CO	2,900 kg	1,700 mg	76 mg
	NOX	720 kg	420 mg	19 mg
	VOC	530 kg	310 mg	14 mg
	Pb	-	-	-
	PM10	140 kg	79 mg	3,600 µg
F, Supply Chain (Vehicles)	Energy	6.7 TJ	3.9 MJ	0.18 MJ
	GHG	89 mt GGE	52 g GGE	2.4 g GGE
	SO2	2,100 kg	1,200 mg	54 mg
	CO	150 kg	87 mg	4.0 mg
	NOX	190 kg	110 mg	5.0 mg
	VOC	13 kg	7.7 mg	0.35 mg
	Pb	0.00086 kg	0.00050 mg	0.023 µg
	PM10	7.0 kg	4.1 mg	190 µg
F, T&D Losses (Vehicles)	Energy	4.3 TJ	2.5 MJ	0.11 MJ
	GHG	25 mt GGE	15 g GGE	0.67 g GGE
	SO2	140 kg	82 mg	3.7 mg
	CO	14 kg	8.3 mg	0.38 mg
	NOX	8.2 kg	4.8 mg	0.22 mg
	VOC	3.8 kg	2.2 mg	0.100 mg
	Pb	0.000092 kg	0.000053 mg	0.0024 µg
	PM10	1.5 kg	0.89 mg	41 µg
F, Supply Chain (Infrastructure)	Energy	2.9 TJ	1.7 MJ	0.078 MJ
	GHG	39 mt GGE	23 g GGE	1.0 g GGE
	SO2	910 kg	530 mg	24 mg
	CO	66 kg	38 mg	1.7 mg
	NOX	83 kg	48 mg	2.2 mg
	VOC	5.9 kg	3.4 mg	0.16 mg
	Pb	0.00038 kg	0.00022 mg	0.010 µg
	PM10	3.1 kg	1.8 mg	82 µg
F, T&D Losses (Infrastructure)	Energy	1.9 TJ	1.1 MJ	0.050 MJ
	GHG	11 mt GGE	6.5 g GGE	0.30 g GGE
	SO2	62 kg	36 mg	1.7 mg
	CO	6.3 kg	3.7 mg	0.17 mg
	NOX	3.6 kg	2.1 mg	0.096 mg
	VOC	1.7 kg	0.96 mg	0.044 mg
	Pb	0.000041 kg	0.000024 mg	0.0011 µg
	PM10	0.68 kg	0.39 mg	18 µg

7.10 Light Rail (Boston's Green Line)

Table 51 – Light Rail (Boston's Green Line) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	1.6 TJ	1.2 MJ	0.021 MJ
	GHG	85 mt GGE	61 g GGE	1.1 g GGE
	SO2	430 kg	310 mg	5.7 mg
	CO	630 kg	450 mg	8.3 mg
	NOX	240 kg	170 mg	3.2 mg
	VOC	58 kg	41 mg	0.76 mg
	Pb	1.5 kg	1.1 mg	20 µg
	PM10	160 kg	110 mg	2,100 µg
V, Operation (Active)	Energy	40 TJ	29 MJ	0.53 MJ
	GHG	5,600 mt GGE	4,000 g GGE	74 g GGE
	SO2	33,000 kg	24,000 mg	440 mg
	CO	6,300 kg	4,500 mg	83 mg
	NOX	7,400 kg	5,300 mg	98 mg
	VOC	430 kg	300 mg	5.6 mg
	Pb	0.28 kg	0.20 mg	3.7 µg
	PM10	340 kg	240 mg	4,400 µg
V, Operation (Idling)	Energy	20 TJ	15 MJ	0.27 MJ
	GHG	2,900 mt GGE	2,100 g GGE	38 g GGE
	SO2	17,000 kg	12,000 mg	220 mg
	CO	3,200 kg	2,300 mg	42 mg
	NOX	3,800 kg	2,700 mg	50 mg
	VOC	220 kg	160 mg	2.9 mg
	Pb	0.14 kg	0.10 mg	1.9 µg
	PM10	170 kg	120 mg	2,300 µg
V, Operation (HVAC)	Energy	6.0 TJ	4.3 MJ	0.079 MJ
	GHG	850 mt GGE	610 g GGE	11 g GGE
	SO2	5,000 kg	3,600 mg	66 mg
	CO	950 kg	680 mg	13 mg
	NOX	1,100 kg	800 mg	15 mg
	VOC	64 kg	46 mg	0.85 mg
	Pb	0.042 kg	0.030 mg	0.55 µg
	PM10	51 kg	36 mg	670 µg
V, Maintenance	Energy	0.31 TJ	0.22 MJ	0.0041 MJ
	GHG	16 mt GGE	11 g GGE	0.20 g GGE
	SO2	44 kg	32 mg	0.58 mg
	CO	54 kg	39 mg	0.72 mg
	NOX	49 kg	35 mg	0.64 mg
	VOC	30 kg	22 mg	0.40 mg
	Pb	0.31 kg	0.22 mg	4.1 µg
	PM10	13 kg	9.3 mg	170 µg
V, Maintenance (Cleaning)	Energy	0.025 TJ	0.018 MJ	0.00033 MJ
	GHG	1.5 mt GGE	1.1 g GGE	0.020 g GGE
	SO2	8.8 kg	6.3 mg	0.12 mg
	CO	1.7 kg	1.2 mg	0.022 mg
	NOX	1.9 kg	1.4 mg	0.026 mg
	VOC	0.11 kg	0.080 mg	0.0015 mg
	Pb	0.000073 kg	0.000052 mg	0.00096 µg
	PM10	0.088 kg	0.063 mg	1.2 µg
V, Maintenance (Flooring)	Energy	0.042 TJ	0.030 MJ	0.00055 MJ
	GHG	3.2 mt GGE	2.3 g GGE	0.042 g GGE
	SO2	6.5 kg	4.6 mg	0.085 mg
	CO	23 kg	16 mg	0.30 mg
	NOX	5.8 kg	4.2 mg	0.077 mg
	VOC	5.3 kg	3.8 mg	0.070 mg
	Pb	-	-	-
	PM10	1.1 kg	0.75 mg	14 µg
V, Insurance (Employees)	Energy	2.3 TJ	1.7 MJ	0.031 MJ
	GHG	190 mt GGE	140 g GGE	2.5 g GGE
	SO2	470 kg	330 mg	6.1 mg
	CO	2,100 kg	1,500 mg	28 mg
	NOX	520 kg	370 mg	6.9 mg
	VOC	390 kg	280 mg	5.1 mg
	Pb	-	-	-
	PM10	99 kg	71 mg	1,300 µg
V, Insurance (Vehicles)	Energy	1.4 TJ	0.97 MJ	0.018 MJ
	GHG	110 mt GGE	80 g GGE	1.5 g GGE
	SO2	270 kg	200 mg	3.6 mg
	CO	1,200 kg	880 mg	16 mg
	NOX	310 kg	220 mg	4.1 mg
	VOC	230 kg	160 mg	3.0 mg
	Pb	-	-	-
	PM10	58 kg	42 mg	770 µg

Table 52 – Light Rail (Boston's Green Line) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	11 TJ	7.9 MJ	0.15 MJ
	GHG	1,100 mt GGE	780 g GGE	14 g GGE
	SO2	3,400 kg	2,400 mg	44 mg
	CO	9,000 kg	6,500 mg	120 mg
	NOX	4,600 kg	3,300 mg	60 mg
	VOC	2,900 kg	2,100 mg	38 mg
	Pb	0.51 kg	0.37 mg	6.8 µg
	PM10	590 kg	420 mg	7,700 µg
I, Station Lighting	Energy	4.8 TJ	3.4 MJ	0.064 MJ
	GHG	680 mt GGE	490 g GGE	9.0 g GGE
	SO2	4,000 kg	2,900 mg	53 mg
	CO	760 kg	550 mg	10 mg
	NOX	900 kg	640 mg	12 mg
	VOC	52 kg	37 mg	0.68 mg
	Pb	0.034 kg	0.024 mg	0.44 µg
	PM10	41 kg	29 mg	540 µg
I, Station Escalators	Energy	0.62 TJ	0.44 MJ	0.0082 MJ
	GHG	88 mt GGE	63 g GGE	1.2 g GGE
	SO2	520 kg	370 mg	6.9 mg
	CO	99 kg	70 mg	1.3 mg
	NOX	120 kg	83 mg	1.5 mg
	VOC	6.7 kg	4.8 mg	0.088 mg
	Pb	0.0043 kg	0.0031 mg	0.057 µg
	PM10	5.3 kg	3.8 mg	69 µg
I, Station Train Control	Energy	3.1 TJ	2.2 MJ	0.041 MJ
	GHG	440 mt GGE	320 g GGE	5.8 g GGE
	SO2	2,600 kg	1,900 mg	35 mg
	CO	500 kg	350 mg	6.6 mg
	NOX	580 kg	420 mg	7.7 mg
	VOC	34 kg	24 mg	0.44 mg
	Pb	0.022 kg	0.016 mg	0.29 µg
	PM10	26 kg	19 mg	350 µg
I, Station Parking Lighting	Energy	0.87 TJ	0.62 MJ	0.012 MJ
	GHG	120 mt GGE	88 g GGE	1.6 g GGE
	SO2	730 kg	520 mg	9.6 mg
	CO	140 kg	99 mg	1.8 mg
	NOX	160 kg	120 mg	2.1 mg
	VOC	9.3 kg	6.7 mg	0.12 mg
	Pb	0.0061 kg	0.0044 mg	0.080 µg
	PM10	7.4 kg	5.3 mg	97 µg
I, Station Miscellaneous	Energy	11 TJ	7.6 MJ	0.14 MJ
	GHG	1,500 mt GGE	1,100 g GGE	20 g GGE
	SO2	8,900 kg	6,400 mg	120 mg
	CO	1,700 kg	1,200 mg	22 mg
	NOX	2,000 kg	1,400 mg	26 mg
	VOC	110 kg	81 mg	1.5 mg
	Pb	0.074 kg	0.053 mg	0.98 µg
	PM10	90 kg	64 mg	1,200 µg
I, Station Maintenance	Energy	0.64 TJ	0.46 MJ	0.0085 MJ
	GHG	64 mt GGE	45 g GGE	0.84 g GGE
	SO2	190 kg	140 mg	2.6 mg
	CO	530 kg	370 mg	6.9 mg
	NOX	270 kg	190 mg	3.5 mg
	VOC	170 kg	120 mg	2.2 mg
	Pb	0.030 kg	0.021 mg	0.39 µg
	PM10	34 kg	24 mg	450 µg
I, Station Cleaning	Energy	0.025 TJ	0.018 MJ	0.00033 MJ
	GHG	1.5 mt GGE	1.1 g GGE	0.020 g GGE
	SO2	8.8 kg	6.3 mg	0.12 mg
	CO	1.7 kg	1.2 mg	0.022 mg
	NOX	1.9 kg	1.4 mg	0.026 mg
	VOC	0.11 kg	0.080 mg	0.0015 mg
	Pb	0.000073 kg	0.000052 mg	0.00096 µg
	PM10	0.088 kg	0.063 mg	1.2 µg
I, Station Parking	Energy	1.3 TJ	0.95 MJ	0.018 MJ
	GHG	110 mt GGE	79 g GGE	1.5 g GGE
	SO2	220 kg	160 mg	2.9 mg
	CO	350 kg	250 mg	4.6 mg
	NOX	560 kg	400 mg	7.4 mg
	VOC	670 kg	480 mg	8.8 mg
	Pb	0.063 kg	0.045 mg	0.84 µg
	PM10	300 kg	210 mg	3,900 µg

(Table 52 continued on the following page…)

Table 52 – Light Rail (Boston's Green Line) Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	11 TJ	8.0 MJ	0.15 MJ
	GHG	1,000 mt GGE	730 g GGE	13 g GGE
	SO2	1,800 kg	1,300 mg	24 mg
	CO	9,800 kg	7,000 mg	130 mg
	NOX	1,600 kg	1,200 mg	22 mg
	VOC	1,000 kg	720 mg	13 mg
	Pb	5.1 kg	3.7 mg	68 µg
	PM10	990 kg	700 mg	13,000 µg
I, Track Maintenance	Energy	1.5 TJ	1.1 MJ	0.020 MJ
	GHG	110 mt GGE	80 g GGE	1.5 g GGE
	SO2	74 kg	53 mg	0.98 mg
	CO	250 kg	180 mg	3.3 mg
	NOX	520 kg	370 mg	6.8 mg
	VOC	54 kg	38 mg	0.71 mg
	Pb	-	-	-
	PM10	54 kg	38 mg	710 µg
I, Insurance (Employees)	Energy	8.5 TJ	6.1 MJ	0.11 MJ
	GHG	700 mt GGE	500 g GGE	9.2 g GGE
	SO2	1,700 kg	1,200 mg	23 mg
	CO	7,700 kg	5,500 mg	100 mg
	NOX	1,900 kg	1,400 mg	25 mg
	VOC	1,400 kg	1,000 mg	19 mg
	Pb	-	-	-
	PM10	360 kg	260 mg	4,800 µg
I, Insurance (Facilities)	Energy	5.4 TJ	3.8 MJ	0.071 MJ
	GHG	440 mt GGE	310 g GGE	5.8 g GGE
	SO2	1,100 kg	770 mg	14 mg
	CO	4,900 kg	3,500 mg	64 mg
	NOX	1,200 kg	870 mg	16 mg
	VOC	900 kg	640 mg	12 mg
	Pb	-	-	-
	PM10	230 kg	160 mg	3,000 µg
F, Supply Chain (Vehicles)	Energy	21 TJ	15 MJ	0.28 MJ
	GHG	410 mt GGE	290 g GGE	5.4 g GGE
	SO2	5,000 kg	3,600 mg	66 mg
	CO	1,400 kg	1,000 mg	19 mg
	NOX	1,400 kg	1,000 mg	19 mg
	VOC	54 kg	38 mg	0.71 mg
	Pb	0.011 kg	0.0081 mg	0.15 µg
	PM10	40 kg	28 mg	520 µg
F, T&D Losses (Vehicles)	Energy	7.0 TJ	5.0 MJ	0.093 MJ
	GHG	110 mt GGE	75 g GGE	1.4 g GGE
	SO2	630 kg	450 mg	8.2 mg
	CO	120 kg	85 mg	1.6 mg
	NOX	140 kg	99 mg	1.8 mg
	VOC	8.0 kg	5.7 mg	0.11 mg
	Pb	0.0052 kg	0.0037 mg	0.069 µg
	PM10	6.3 kg	4.5 mg	83 µg
F, Supply Chain (Infrastructure)	Energy	6.5 TJ	4.6 MJ	0.086 MJ
	GHG	120 mt GGE	89 g GGE	1.6 g GGE
	SO2	1,500 kg	1,100 mg	20 mg
	CO	430 kg	300 mg	5.6 mg
	NOX	430 kg	310 mg	5.7 mg
	VOC	16 kg	12 mg	0.21 mg
	Pb	0.0034 kg	0.0025 mg	0.045 µg
	PM10	12 kg	8.6 mg	160 µg
F, T&D Losses (Infrastructure)	Energy	2.1 TJ	1.5 MJ	0.028 MJ
	GHG	32 mt GGE	23 g GGE	0.42 g GGE
	SO2	190 kg	140 mg	2.5 mg
	CO	36 kg	26 mg	0.47 mg
	NOX	42 kg	30 mg	0.56 mg
	VOC	2.4 kg	1.7 mg	0.032 mg
	Pb	0.0016 kg	0.0011 mg	0.021 µg
	PM10	1.9 kg	1.4 mg	25 µg

8 Supporting Data for High Speed Rail and Air Modes

In addition to the supplemental and updated metropolitan onroad and rail modes, California High Speed Rail and small to large aircraft have been inventories. While no major inventory updates have occurred for these modes from Chester (2009), they are reported here for comparisons. These inventories are found in the following sections:

8.1 High Speed Rail (California) Life-cycle Inventory

Table 53 – High Speed Rail (California) Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Manufacture	Energy	44 TJ	2.8 MJ	0.0037 MJ
	GHG	2,100 mt GGE	140 g GGE	0.18 g GGE
	SO2	10,000 kg	640 mg	0.85 mg
	CO	8,400 kg	540 mg	0.71 mg
	NOX	5,600 kg	360 mg	0.47 mg
	VOC	1,700 kg	110 mg	0.14 mg
	Pb	25 kg	1.6 mg	2.1 µg
	PM10	3,100 kg	200 mg	260 µg
V, Operation (Active)	Energy	14,000 TJ	900 MJ	1.2 MJ
	GHG	1,000,000 mt GGE	66,000 g GGE	87 g GGE
	SO2	5,500,000 kg	350,000 mg	470 mg
	CO	530,000 kg	34,000 mg	45 mg
	NOX	400,000 kg	26,000 mg	34 mg
	VOC	120,000 kg	7,600 mg	10 mg
	Pb	7.2 kg	0.46 mg	0.60 µg
	PM10	60,000 kg	3,800 mg	5,100 µg
V, Operation (Idling)	Energy	350 TJ	23 MJ	0.030 MJ
	GHG	26,000 mt GGE	1,700 g GGE	2.2 g GGE
	SO2	140,000 kg	8,900 mg	12 mg
	CO	13,000 kg	850 mg	1.1 mg
	NOX	10,000 kg	640 mg	0.84 mg
	VOC	3,000 kg	190 mg	0.25 mg
	Pb	0.18 kg	0.012 mg	0.015 µg
	PM10	1,500 kg	96 mg	130 µg
V, Operation (HVAC)	Energy	760 TJ	49 MJ	0.064 MJ
	GHG	56,000 mt GGE	3,600 g GGE	4.7 g GGE
	SO2	300,000 kg	19,000 mg	25 mg
	CO	29,000 kg	1,800 mg	2.4 mg
	NOX	22,000 kg	1,400 mg	1.8 mg
	VOC	6,400 kg	410 mg	0.54 mg
	Pb	0.39 kg	0.025 mg	0.033 µg
	PM10	3,200 kg	210 mg	270 µg
V, Maintenance	Energy	28 TJ	1.8 MJ	0.0024 MJ
	GHG	1,300 mt GGE	85 g GGE	0.11 g GGE
	SO2	1,200 kg	77 mg	0.10 mg
	CO	2,600 kg	170 mg	0.22 mg
	NOX	2,500 kg	160 mg	0.21 mg
	VOC	4,000 kg	260 mg	0.34 mg
	Pb	1.8 kg	0.12 mg	0.16 µg
	PM10	390 kg	25 mg	33 µg
V, Maintenance (Cleaning)	Energy	0.12 TJ	0.0074 MJ	0.0000098 MJ
	GHG	8.5 mt GGE	0.55 g GGE	0.00072 g GGE
	SO2	46 kg	2.9 mg	0.0038 mg
	CO	4.4 kg	0.28 mg	0.00037 mg
	NOX	3.3 kg	0.21 mg	0.00028 mg
	VOC	0.98 kg	0.063 mg	0.000082 mg
	Pb	0.000059 kg	0.0000038 mg	0.0000050 µg
	PM10	0.49 kg	0.032 mg	0.042 µg
V, Maintenance (Flooring)	Energy	4.6 TJ	0.29 MJ	0.00039 MJ
	GHG	360 mt GGE	23 g GGE	0.030 g GGE
	SO2	660 kg	42 mg	0.055 mg
	CO	3,400 kg	220 mg	0.29 mg
	NOX	660 kg	42 mg	0.055 mg
	VOC	590 kg	38 mg	0.050 mg
	Pb	0.32 kg	0.020 mg	0.027 µg
	PM10	230 kg	15 mg	19 µg
V, Insurance (Employees)	Energy	7.9 TJ	0.50 MJ	0.00066 MJ
	GHG	640 mt GGE	41 g GGE	0.054 g GGE
	SO2	1,600 kg	100 mg	0.13 mg
	CO	7,100 kg	460 mg	0.60 mg
	NOX	1,800 kg	110 mg	0.15 mg
	VOC	1,300 kg	85 mg	0.11 mg
	Pb	-	-	-
	PM10	340 kg	22 mg	28 µg
V, Insurance (Vehicles)	Energy	11 TJ	0.73 MJ	0.00096 MJ
	GHG	930 mt GGE	60 g GGE	0.078 g GGE
	SO2	2,300 kg	150 mg	0.19 mg
	CO	10,000 kg	660 mg	0.87 mg
	NOX	2,600 kg	160 mg	0.22 mg
	VOC	1,900 kg	120 mg	0.16 mg
	Pb	-	-	-
	PM10	490 kg	31 mg	41 µg

Table 54 – High Speed Rail (California) Life-cycle Infrastructure & Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Station Construction	Energy	11 TJ	0.69 MJ	0.00090 MJ
	GHG	1,100 mt GGE	68 g GGE	0.090 g GGE
	SO2	3,300 kg	210 mg	0.27 mg
	CO	8,800 kg	560 mg	0.74 mg
	NOX	4,400 kg	280 mg	0.37 mg
	VOC	2,800 kg	180 mg	0.24 mg
	Pb	0.50 kg	0.032 mg	0.042 µg
	PM10	570 kg	37 mg	48 µg
I, Station Lighting	Energy	0.15 TJ	0.0094 MJ	0.000012 MJ
	GHG	11 mt GGE	0.69 g GGE	0.00091 g GGE
	SO2	58 kg	3.7 mg	0.0049 mg
	CO	5.6 kg	0.36 mg	0.00047 mg
	NOX	4.2 kg	0.27 mg	0.00035 mg
	VOC	1.2 kg	0.080 mg	0.00010 mg
	Pb	0.000075 kg	0.0000048 mg	0.0000063 µg
	PM10	0.63 kg	0.040 mg	0.053 µg
I, Station Escalators	Energy	0.066 TJ	0.0042 MJ	0.0000055 MJ
	GHG	4.8 mt GGE	0.31 g GGE	0.00041 g GGE
	SO2	26 kg	1.6 mg	0.0022 mg
	CO	2.5 kg	0.16 mg	0.00021 mg
	NOX	1.9 kg	0.12 mg	0.00016 mg
	VOC	0.56 kg	0.035 mg	0.000047 mg
	Pb	0.000034 kg	0.0000021 mg	0.0000028 µg
	PM10	0.28 kg	0.018 mg	0.024 µg
I, Station Train Control	Energy	180 TJ	11 MJ	0.015 MJ
	GHG	13,000 mt GGE	830 g GGE	1.1 g GGE
	SO2	69,000 kg	4,400 mg	5.8 mg
	CO	6,700 kg	430 mg	0.56 mg
	NOX	5,000 kg	320 mg	0.42 mg
	VOC	1,500 kg	95 mg	0.13 mg
	Pb	0.090 kg	0.0057 mg	0.0076 µg
	PM10	750 kg	48 mg	63 µg
I, Station Parking Lighting	Energy	19 TJ	1.2 MJ	0.0016 MJ
	GHG	1,400 mt GGE	90 g GGE	0.12 g GGE
	SO2	7,500 kg	480 mg	0.63 mg
	CO	730 kg	46 mg	0.061 mg
	NOX	540 kg	35 mg	0.046 mg
	VOC	160 kg	10 mg	0.014 mg
	Pb	0.0098 kg	0.00063 mg	0.00082 µg
	PM10	82 kg	5.2 mg	6.9 µg
I, Station Miscellaneous	Energy	0.034 TJ	0.0022 MJ	0.0000029 MJ
	GHG	2.5 mt GGE	0.16 g GGE	0.00021 g GGE
	SO2	13 kg	0.85 mg	0.0011 mg
	CO	1.3 kg	0.082 mg	0.00011 mg
	NOX	0.96 kg	0.062 mg	0.000081 mg
	VOC	0.29 kg	0.018 mg	0.000024 mg
	Pb	0.000017 kg	0.0000011 mg	0.0000015 µg
	PM10	0.14 kg	0.0093 mg	0.012 µg
I, Station Maintenance	Energy	0.65 TJ	0.041 MJ	0.000054 MJ
	GHG	64 mt GGE	4.1 g GGE	0.0054 g GGE
	SO2	200 kg	13 mg	0.017 mg
	CO	530 kg	34 mg	0.045 mg
	NOX	270 kg	17 mg	0.023 mg
	VOC	170 kg	11 mg	0.014 mg
	Pb	0.030 kg	0.0019 mg	0.0025 µg
	PM10	34 kg	2.2 mg	2.9 µg
I, Station Cleaning	Energy	0.12 TJ	0.0074 MJ	0.0000098 MJ
	GHG	8.5 mt GGE	0.55 g GGE	0.00072 g GGE
	SO2	46 kg	2.9 mg	0.0038 mg
	CO	4.4 kg	0.28 mg	0.00037 mg
	NOX	3.3 kg	0.21 mg	0.00028 mg
	VOC	0.98 kg	0.063 mg	0.000082 mg
	Pb	0.000059 kg	0.0000038 mg	0.0000050 µg
	PM10	0.49 kg	0.032 mg	0.042 µg
I, Station Parking	Energy	44 TJ	2.8 MJ	0.0037 MJ
	GHG	3,700 mt GGE	240 g GGE	0.31 g GGE
	SO2	7,200 kg	460 mg	0.60 mg
	CO	11,000 kg	730 mg	0.96 mg
	NOX	19,000 kg	1,200 mg	1.6 mg
	VOC	22,000 kg	1,400 mg	1.9 mg
	Pb	2.1 kg	0.13 mg	0.18 µg
	PM10	9,800 kg	630 mg	830 µg

(Table 54 continued on the following page…)

Table 54 – High Speed Rail (California) Life-cycle Infrastructure & Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I,Track/Power Construction	Energy	3,800 TJ	240 MJ	0.32 MJ
	GHG	360,000 mt GGE	23,000 g GGE	30 g GGE
	SO2	1,100,000 kg	69,000 mg	91 mg
	CO	3,000,000 kg	190,000 mg	250 mg
	NOX	1,300,000 kg	86,000 mg	110 mg
	VOC	950,000 kg	61,000 mg	80 mg
	Pb	280 kg	18 mg	23 µg
	PM10	190,000 kg	12,000 mg	16,000 µg
I, Track Maintenance	Energy	96 TJ	6.1 MJ	0.0081 MJ
	GHG	4,000 mt GGE	260 g GGE	0.34 g GGE
	SO2	3,700 kg	240 mg	0.31 mg
	CO	1,900 kg	120 mg	0.16 mg
	NOX	6,600 kg	420 mg	0.55 mg
	VOC	1,300 kg	83 mg	0.11 mg
	Pb	4.4 kg	0.28 mg	0.37 µg
	PM10	1,100 kg	72 mg	94 µg
I, Insurance (Employees)	Energy	37 TJ	2.4 MJ	0.0031 MJ
	GHG	3,000 mt GGE	190 g GGE	0.26 g GGE
	SO2	7,500 kg	480 mg	0.63 mg
	CO	34,000 kg	2,200 mg	2.8 mg
	NOX	8,400 kg	540 mg	0.71 mg
	VOC	6,300 kg	400 mg	0.53 mg
	Pb	-	-	-
	PM10	1,600 kg	100 mg	130 µg
I, Insurance (Facilities)	Energy	33 TJ	2.1 MJ	0.0027 MJ
	GHG	2,700 mt GGE	170 g GGE	0.22 g GGE
	SO2	6,600 kg	420 mg	0.55 mg
	CO	30,000 kg	1,900 mg	2.5 mg
	NOX	7,400 kg	470 mg	0.62 mg
	VOC	5,500 kg	350 mg	0.46 mg
	Pb	-	-	-
	PM10	1,400 kg	89 mg	120 µg
F, Supply Chain (Vehicles)	Energy	2,200 TJ	140 MJ	0.18 MJ
	GHG	38,000 mt GGE	2,400 g GGE	3.2 g GGE
	SO2	840,000 kg	53,000 mg	70 mg
	CO	58,000 kg	3,700 mg	4.9 mg
	NOX	95,000 kg	6,100 mg	8.0 mg
	VOC	4,400 kg	280 mg	0.37 mg
	Pb	0.70 kg	0.045 mg	0.059 µg
	PM10	2,900 kg	180 mg	240 µg
F, T&D Losses (Vehicles)	Energy	1,400 TJ	89 MJ	0.12 MJ
	GHG	9,400 mt GGE	600 g GGE	0.79 g GGE
	SO2	50,000 kg	3,200 mg	4.2 mg
	CO	4,800 kg	310 mg	0.41 mg
	NOX	3,600 kg	230 mg	0.30 mg
	VOC	1,100 kg	69 mg	0.091 mg
	Pb	0.065 kg	0.0042 mg	0.0055 µg
	PM10	550 kg	35 mg	46 µg
F, Supply Chain (Infrastructure)	Energy	28 TJ	1.8 MJ	0.0024 MJ
	GHG	490 mt GGE	31 g GGE	0.041 g GGE
	SO2	11,000 kg	690 mg	0.90 mg
	CO	740 kg	48 mg	0.063 mg
	NOX	1,200 kg	78 mg	0.10 mg
	VOC	56 kg	3.6 mg	0.0047 mg
	Pb	0.0090 kg	0.00058 mg	0.00076 µg
	PM10	37 kg	2.3 mg	3.1 µg
F, T&D Losses (Infrastructure)	Energy	18 TJ	1.2 MJ	0.0015 MJ
	GHG	120 mt GGE	7.7 g GGE	0.010 g GGE
	SO2	650 kg	41 mg	0.054 mg
	CO	62 kg	4.0 mg	0.0052 mg
	NOX	47 kg	3.0 mg	0.0039 mg
	VOC	14 kg	0.89 mg	0.0012 mg
	Pb	0.00084 kg	0.000054 mg	0.000071 µg
	PM10	7.0 kg	0.45 mg	0.59 µg

8.2 Small Aircraft Life-cycle Inventory

Table 55 – Small Aircraft Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Aircraft Manufacture	Energy	63,000 GJ	4,600 kJ	140 kJ
	GHG	5,100 mt GGE	370 g GGE	11 g GGE
	SO2	13,000 kg	970 mg	29 mg
	CO	50,000 kg	3,700 mg	110 mg
	NOX	11,000 kg	810 mg	24 mg
	VOC	8,300 kg	610 mg	18 mg
	Pb	11 kg	0.80 mg	0.024 mg
	PM10	3,100 kg	230 mg	6.8 mg
V, Engine Manufacture	Energy	22,000 GJ	1,600 kJ	48 kJ
	GHG	1,800 mt GGE	130 g GGE	3.9 g GGE
	SO2	5,000 kg	360 mg	11 mg
	CO	15,000 kg	1,100 mg	33 mg
	NOX	3,900 kg	290 mg	8.6 mg
	VOC	2,300 kg	170 mg	5.0 mg
	Pb	4.3 kg	0.31 mg	0.0094 mg
	PM10	1,100 kg	81 mg	2.4 mg
V, Operation, APU	Energy	14,000 GJ	1,000 kJ	31 kJ
	GHG	950 mt GGE	69 g GGE	2.1 g GGE
	SO2	880 kg	64 mg	1.9 mg
	CO	5,700 kg	420 mg	12 mg
	NOX	4,000 kg	300 mg	8.9 mg
	VOC	540 kg	39 mg	1.2 mg
	Pb	-	-	-
	PM10	-	-	-
V, Operation, Startup	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	14,000 kg	1,000 mg	31 mg
	Pb	-	-	-
	PM10	-	-	-
V, Operation, Taxi	Energy	180,000 GJ	13,000 kJ	400 kJ
	GHG	12,000 mt GGE	880 g GGE	26 g GGE
	SO2	5,200 kg	380 mg	12 mg
	CO	64,000 kg	4,700 mg	140 mg
	NOX	15,000 kg	1,100 mg	33 mg
	VOC	8,800 kg	650 mg	19 mg
	Pb	-	-	-
	PM10	590 kg	43 mg	1.3 mg
V, Operation, Take Off	Energy	47,000 GJ	3,400 kJ	100 kJ
	GHG	3,100 mt GGE	230 g GGE	6.9 g GGE
	SO2	1,400 kg	100 mg	3.0 mg
	CO	810 kg	59 mg	1.8 mg
	NOX	21,000 kg	1,500 mg	46 mg
	VOC	250 kg	18 mg	0.54 mg
	Pb	-	-	-
	PM10	270 kg	20 mg	0.59 mg
V, Operation, Climb Out	Energy	120,000 GJ	9,100 kJ	270 kJ
	GHG	8,200 mt GGE	600 g GGE	18 g GGE
	SO2	3,600 kg	260 mg	7.9 mg
	CO	2,100 kg	160 mg	4.7 mg
	NOX	47,000 kg	3,500 mg	100 mg
	VOC	650 kg	48 mg	1.4 mg
	Pb	-	-	-
	PM10	630 kg	46 mg	1.4 mg

(Table 55 continued on next page)

Table 55 – Small Aircraft Life-cycle Vehicle Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Operation, Cruise	Energy	1,100,000 GJ	78,000 kJ	2,300 kJ
	GHG	71,000 mt GGE	5,200 g GGE	160 g GGE
	SO2	23,000 kg	1,700 mg	50 mg
	CO	31,000 kg	2,300 mg	68 mg
	NOX	180,000 kg	13,000 mg	390 mg
	VOC	3,900 kg	280 mg	8.6 mg
	Pb	-	-	-
	PM10	910 kg	66 mg	2.0 mg
V, Operation, Approach	Energy	84,000 GJ	6,100 kJ	180 kJ
	GHG	5,600 mt GGE	410 g GGE	12 g GGE
	SO2	2,400 kg	180 mg	5.4 mg
	CO	5,700 kg	410 mg	12 mg
	NOX	14,000 kg	1,000 mg	31 mg
	VOC	1,000 kg	77 mg	2.3 mg
	Pb	-	-	-
	PM10	390 kg	29 mg	0.87 mg
V, Operation, Taxi In	Energy	66,000 GJ	4,900 kJ	150 kJ
	GHG	4,400 mt GGE	320 g GGE	9.7 g GGE
	SO2	1,900 kg	140 mg	4.2 mg
	CO	24,000 kg	1,700 mg	52 mg
	NOX	5,600 kg	410 mg	12 mg
	VOC	3,200 kg	240 mg	7.1 mg
	Pb	-	-	-
	PM10	220 kg	16 mg	0.48 mg
V, Maintenance, Lubrication & Fuel	Energy	5,300 GJ	390 kJ	12 kJ
	GHG	350 mt GGE	25 g GGE	0.76 g GGE
	SO2	190 kg	14 mg	0.41 mg
	CO	620 kg	45 mg	1.4 mg
	NOX	170 kg	12 mg	0.37 mg
	VOC	160 kg	11 mg	0.34 mg
	Pb	-	-	-
	PM10	32 kg	2.4 mg	0.071 mg
V, Maintenance, Battery	Energy	660 GJ	48 kJ	1.4 kJ
	GHG	50 mt GGE	3.7 g GGE	0.11 g GGE
	SO2	120 kg	9.1 mg	0.27 mg
	CO	650 kg	47 mg	1.4 mg
	NOX	110 kg	7.8 mg	0.24 mg
	VOC	84 kg	6.1 mg	0.18 mg
	Pb	0.35 kg	0.025 mg	0.00076 mg
	PM10	34 kg	2.5 mg	0.074 mg
V, Maintenance, Chemical Application	Energy	2,100 GJ	160 kJ	4.7 kJ
	GHG	190 mt GGE	14 g GGE	0.42 g GGE
	SO2	360 kg	27 mg	0.80 mg
	CO	520 kg	38 mg	1.1 mg
	NOX	210 kg	16 mg	0.47 mg
	VOC	240 kg	17 mg	0.52 mg
	Pb	-	-	-
	PM10	38 kg	2.8 mg	0.083 mg
V, Maintenance, Parts Cleaning	Energy	1,900 GJ	140 kJ	4.1 kJ
	GHG	160 mt GGE	12 g GGE	0.36 g GGE
	SO2	260 kg	19 mg	0.57 mg
	CO	680 kg	50 mg	1.5 mg
	NOX	230 kg	17 mg	0.51 mg
	VOC	300 kg	22 mg	0.67 mg
	Pb	-	-	-
	PM10	46 kg	3.3 mg	0.10 mg

(Table 55 continued on next page)

Table 55 – Small Aircraft Life-cycle Vehicle Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Maintenance, Metal Finishing	Energy	3,100 GJ	230 kJ	6.9 kJ
	GHG	180 mt GGE	13 g GGE	0.40 g GGE
	SO2	500 kg	37 mg	1.1 mg
	CO	480 kg	35 mg	1.0 mg
	NOX	220 kg	16 mg	0.48 mg
	VOC	110 kg	7.7 mg	0.23 mg
	Pb	-	-	-
	PM10	49 kg	3.6 mg	0.11 mg
V, Maintenance, Coating Application	Energy	1,400 GJ	100 kJ	3.1 kJ
	GHG	100 mt GGE	7.5 g GGE	0.22 g GGE
	SO2	190 kg	14 mg	0.43 mg
	CO	860 kg	63 mg	1.9 mg
	NOX	170 kg	13 mg	0.38 mg
	VOC	250 kg	19 mg	0.56 mg
	Pb	0.35 kg	0.025 mg	0.00076 mg
	PM10	64 kg	4.7 mg	0.14 mg
V, Maintenance, Depainting	Energy	3,100 GJ	230 kJ	6.9 kJ
	GHG	180 mt GGE	13 g GGE	0.40 g GGE
	SO2	500 kg	37 mg	1.1 mg
	CO	480 kg	35 mg	1.0 mg
	NOX	220 kg	16 mg	0.48 mg
	VOC	110 kg	7.7 mg	0.23 mg
	Pb	-	-	-
	PM10	49 kg	3.6 mg	0.11 mg
V, Maintenance, Painting	Energy	4,200 GJ	310 kJ	9.2 kJ
	GHG	310 mt GGE	22 g GGE	0.67 g GGE
	SO2	580 kg	42 mg	1.3 mg
	CO	2,600 kg	190 mg	5.7 mg
	NOX	520 kg	38 mg	1.2 mg
	VOC	760 kg	56 mg	1.7 mg
	Pb	1.0 kg	0.076 mg	0.0023 mg
	PM10	190 kg	14 mg	0.42 mg
V, Maintenance, Engine	Energy	1,600 GJ	110 kJ	3.4 kJ
	GHG	120 mt GGE	9.1 g GGE	0.27 g GGE
	SO2	350 kg	26 mg	0.77 mg
	CO	1,100 kg	78 mg	2.3 mg
	NOX	280 kg	20 mg	0.61 mg
	VOC	160 kg	12 mg	0.35 mg
	Pb	0.30 kg	0.022 mg	0.00067 mg
	PM10	78 kg	5.7 mg	0.17 mg
V, Insurance, Incidents	Energy	300 GJ	22 kJ	0.65 kJ
	GHG	24 mt GGE	1.8 g GGE	0.053 g GGE
	SO2	60 kg	4.4 mg	0.13 mg
	CO	270 kg	20 mg	0.59 mg
	NOX	67 kg	4.9 mg	0.15 mg
	VOC	50 kg	3.6 mg	0.11 mg
	Pb	-	-	-
	PM10	13 kg	0.93 mg	0.028 mg
V, Insurance, Health	Energy	670 GJ	49 kJ	1.5 kJ
	GHG	54 mt GGE	4.0 g GGE	0.12 g GGE
	SO2	130 kg	9.8 mg	0.29 mg
	CO	600 kg	44 mg	1.3 mg
	NOX	150 kg	11 mg	0.33 mg
	VOC	110 kg	8.2 mg	0.25 mg
	Pb	-	-	-
	PM10	28 kg	2.1 mg	0.062 mg

(Table 55 continued on next page)

Table 56 – Small Aircraft Life-cycle Infrastructure and Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Construction, Airports	Energy	520 GJ	38 kJ	1.1 kJ
	GHG	41 mt GGE	3.0 g GGE	0.089 g GGE
	SO2	71 kg	5.2 mg	0.16 mg
	CO	370 kg	27 mg	0.82 mg
	NOX	140 kg	10.0 mg	0.30 mg
	VOC	68 kg	5.0 mg	0.15 mg
	Pb	-	-	-
	PM10	28 kg	2.0 mg	0.061 mg
I, Construction, Runways	Energy	7,300 GJ	530 kJ	16 kJ
	GHG	670 mt GGE	49 g GGE	1.5 g GGE
	SO2	3,400 kg	250 mg	7.4 mg
	CO	4,800 kg	350 mg	10 mg
	NOX	2,900 kg	220 mg	6.5 mg
	VOC	-	-	-
	Pb	0.50 kg	0.037 mg	0.0011 mg
	PM10	570 kg	42 mg	1.3 mg
I, Construction, Tarmacs	Energy	19,000 GJ	1,400 kJ	42 kJ
	GHG	1,800 mt GGE	130 g GGE	3.9 g GGE
	SO2	8,800 kg	650 mg	19 mg
	CO	13,000 kg	920 mg	28 mg
	NOX	7,700 kg	560 mg	17 mg
	VOC	-	-	-
	Pb	1.3 kg	0.096 mg	0.0029 mg
	PM10	1,500 kg	110 mg	3.3 mg
I, Operation, Runway Lighting	Energy	1,200 GJ	89 kJ	2.7 kJ
	GHG	250 mt GGE	19 g GGE	0.56 g GGE
	SO2	1,300 kg	93 mg	2.8 mg
	CO	120 kg	9.0 mg	0.27 mg
	NOX	420 kg	31 mg	0.92 mg
	VOC	11 kg	0.80 mg	0.024 mg
	Pb	0.020 kg	0.0015 mg	0.000044 mg
	PM10	14 kg	1.0 mg	0.031 mg
I, Operation, Other Electricity	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
I, Operation, Deicing Fluid Production	Energy	1,900 GJ	140 kJ	4.2 kJ
	GHG	140 mt GGE	10 g GGE	0.31 g GGE
	SO2	580 kg	43 mg	1.3 mg
	CO	900 kg	66 mg	2.0 mg
	NOX	610 kg	45 mg	1.3 mg
	VOC	290 kg	21 mg	0.64 mg
	Pb	-	-	-
	PM10	91 kg	6.6 mg	0.20 mg
I, Operation, Ground Support Equipment	Energy	15,000 GJ	1,100 kJ	33 kJ
	GHG	1,200 mt GGE	85 g GGE	2.5 g GGE
	SO2	860 kg	63 mg	1.9 mg
	CO	84,000 kg	6,100 mg	180 mg
	NOX	12,000 kg	850 mg	25 mg
	VOC	3,100 kg	230 mg	6.8 mg
	Pb	-	-	-
	PM10	500 kg	37 mg	1.1 mg

(Table 56 continued on next page)

Table 56 – Small Aircraft Life-cycle Infrastructure and Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Maintenance, Airports	Energy	26 GJ	1.9 kJ	0.057 kJ
	GHG	2.0 mt GGE	0.15 g GGE	0.0045 g GGE
	SO2	3.6 kg	0.26 mg	0.0078 mg
	CO	19 kg	1.4 mg	0.041 mg
	NOX	6.8 kg	0.50 mg	0.015 mg
	VOC	3.4 kg	0.25 mg	0.0075 mg
	Pb	-	-	-
	PM10	1.4 kg	0.10 mg	0.0031 mg
I, Maintenance, Runways	Energy	580 GJ	43 kJ	1.3 kJ
	GHG	83 mt GGE	6.1 g GGE	0.18 g GGE
	SO2	210 kg	15 mg	0.45 mg
	CO	630 kg	46 mg	1.4 mg
	NOX	290 kg	21 mg	0.64 mg
	VOC	-	-	-
	Pb	0.077 kg	0.0057 mg	0.00017 mg
	PM10	68 kg	5.0 mg	0.15 mg
I, Maintenance, Tarmacs	Energy	1,500 GJ	110 kJ	3.4 kJ
	GHG	220 mt GGE	16 g GGE	0.48 g GGE
	SO2	540 kg	39 mg	1.2 mg
	CO	1,700 kg	120 mg	3.7 mg
	NOX	770 kg	56 mg	1.7 mg
	VOC	-	-	-
	Pb	0.20 kg	0.015 mg	0.00045 mg
	PM10	180 kg	13 mg	0.40 mg
I, Parking	Energy	6,400 GJ	470 kJ	14 kJ
	GHG	610 mt GGE	45 g GGE	1.3 g GGE
	SO2	3,300 kg	240 mg	7.2 mg
	CO	4,400 kg	320 mg	9.7 mg
	NOX	2,600 kg	190 mg	5.7 mg
	VOC	-	-	-
	Pb	0.37 kg	0.027 mg	0.00082 mg
	PM10	480 kg	35 mg	1.0 mg
I, Insurance, Non-Operator	Energy	1,100 GJ	82 kJ	2.5 kJ
	GHG	91 mt GGE	6.7 g GGE	0.20 g GGE
	SO2	220 kg	16 mg	0.49 mg
	CO	1,000 kg	74 mg	2.2 mg
	NOX	250 kg	19 mg	0.56 mg
	VOC	190 kg	14 mg	0.41 mg
	Pb	-	-	-
	PM10	48 kg	3.5 mg	0.10 mg
I, Insurance, Liability	Energy	130 GJ	9.2 kJ	0.28 kJ
	GHG	10 mt GGE	0.75 g GGE	0.023 g GGE
	SO2	25 kg	1.8 mg	0.055 mg
	CO	110 kg	8.3 mg	0.25 mg
	NOX	28 kg	2.1 mg	0.062 mg
	VOC	21 kg	1.5 mg	0.046 mg
	Pb	-	-	-
	PM10	5.4 kg	0.39 mg	0.012 mg
I, Insurance, Liability	Energy	26 GJ	1.9 kJ	0.057 kJ
	GHG	2.0 mt GGE	0.15 g GGE	0.0045 g GGE
	SO2	3.6 kg	0.26 mg	0.0078 mg
	CO	19 kg	1.4 mg	0.041 mg
	NOX	6.8 kg	0.50 mg	0.015 mg
	VOC	3.4 kg	0.25 mg	0.0075 mg
	Pb	-	-	-
	PM10	1.4 kg	0.10 mg	0.0031 mg
F, Refining & Distribution	Energy	160,000 GJ	11,000 kJ	340 kJ
	GHG	14,000 mt GGE	1,000 g GGE	31 g GGE
	SO2	26,000 kg	1,900 mg	58 mg
	CO	39,000 kg	2,900 mg	86 mg
	NOX	25,000 kg	1,800 mg	54 mg
	VOC	17,000 kg	1,200 mg	37 mg
	Pb	-	-	-
	PM10	4,000 kg	290 mg	8.7 mg

8.3 Midsize Aircraft Life-cycle Inventory

Table 57 – Midsize Aircraft Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Aircraft Manufacture	Energy	210,000 GJ	4,200 kJ	41 kJ
	GHG	17,000 mt GGE	340 g GGE	3.3 g GGE
	SO2	44,000 kg	880 mg	8.7 mg
	CO	170,000 kg	3,300 mg	33 mg
	NOX	37,000 kg	730 mg	7.2 mg
	VOC	27,000 kg	550 mg	5.4 mg
	Pb	36 kg	0.73 mg	0.0072 mg
	PM10	10,000 kg	200 mg	2.0 mg
V, Engine Manufacture	Energy	42,000 GJ	830 kJ	8.2 kJ
	GHG	3,300 mt GGE	67 g GGE	0.66 g GGE
	SO2	9,400 kg	190 mg	1.9 mg
	CO	28,000 kg	570 mg	5.6 mg
	NOX	7,400 kg	150 mg	1.5 mg
	VOC	4,300 kg	86 mg	0.84 mg
	Pb	8.1 kg	0.16 mg	0.0016 mg
	PM10	2,100 kg	42 mg	0.41 mg
V, Operation, APU	Energy	99,000 GJ	2,000 kJ	20 kJ
	GHG	6,600 mt GGE	130 g GGE	1.3 g GGE
	SO2	2,400 kg	47 mg	0.47 mg
	CO	43,000 kg	850 mg	8.4 mg
	NOX	11,000 kg	220 mg	2.2 mg
	VOC	2,400 kg	49 mg	0.48 mg
	Pb	-	-	-
	PM10	-	-	-
V, Operation, Startup	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	45,000 kg	890 mg	8.8 mg
	Pb	-	-	-
	PM10	-	-	-
V, Operation, Taxi	Energy	710,000 GJ	14,000 kJ	140 kJ
	GHG	47,000 mt GGE	950 g GGE	9.4 g GGE
	SO2	21,000 kg	410 mg	4.1 mg
	CO	500,000 kg	10,000 mg	100 mg
	NOX	61,000 kg	1,200 mg	12 mg
	VOC	32,000 kg	630 mg	6.3 mg
	Pb	-	-	-
	PM10	3,700 kg	74 mg	0.73 mg
V, Operation, Take Off	Energy	200,000 GJ	4,000 kJ	40 kJ
	GHG	13,000 mt GGE	270 g GGE	2.6 g GGE
	SO2	5,800 kg	120 mg	1.1 mg
	CO	3,800 kg	76 mg	0.75 mg
	NOX	78,000 kg	1,600 mg	15 mg
	VOC	180 kg	3.5 mg	0.035 mg
	Pb	-	-	-
	PM10	920 kg	18 mg	0.18 mg
V, Operation, Climb Out	Energy	530,000 GJ	11,000 kJ	100 kJ
	GHG	35,000 mt GGE	700 g GGE	6.9 g GGE
	SO2	15,000 kg	310 mg	3.0 mg
	CO	10,000 kg	200 mg	2.0 mg
	NOX	180,000 kg	3,600 mg	35 mg
	VOC	460 kg	9.3 mg	0.091 mg
	Pb	-	-	-
	PM10	2,100 kg	42 mg	0.41 mg

(Table 57 continued on next page)

Table 57 – Midsize Aircraft Life-cycle Vehicle Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Operation, Cruise	Energy	11,000,000 GJ	220,000 kJ	2,100 kJ
	GHG	730,000 mt GGE	15,000 g GGE	140 g GGE
	SO2	230,000 kg	4,600 mg	46 mg
	CO	410,000 kg	8,100 mg	80 mg
	NOX	2,600,000 kg	51,000 mg	500 mg
	VOC	22,000 kg	450 mg	4.4 mg
	Pb	-	-	-
	PM10	9,300 kg	190 mg	1.8 mg
V, Operation, Approach	Energy	350,000 GJ	7,100 kJ	70 kJ
	GHG	24,000 mt GGE	470 g GGE	4.7 g GGE
	SO2	10,000 kg	210 mg	2.0 mg
	CO	28,000 kg	560 mg	5.5 mg
	NOX	64,000 kg	1,300 mg	13 mg
	VOC	550 kg	11 mg	0.11 mg
	Pb	-	-	-
	PM10	1,500 kg	31 mg	0.30 mg
V, Operation, Taxi In	Energy	260,000 GJ	5,300 kJ	52 kJ
	GHG	18,000 mt GGE	350 g GGE	3.5 g GGE
	SO2	7,600 kg	150 mg	1.5 mg
	CO	190,000 kg	3,700 mg	37 mg
	NOX	22,000 kg	450 mg	4.4 mg
	VOC	12,000 kg	230 mg	2.3 mg
	Pb	-	-	-
	PM10	1,400 kg	27 mg	0.27 mg
V, Maintenance, Lubrication & Fuel	Energy	61,000 GJ	1,200 kJ	12 kJ
	GHG	4,000 mt GGE	80 g GGE	0.79 g GGE
	SO2	2,100 kg	43 mg	0.42 mg
	CO	7,200 kg	140 mg	1.4 mg
	NOX	2,000 kg	39 mg	0.39 mg
	VOC	1,800 kg	36 mg	0.36 mg
	Pb	-	-	-
	PM10	370 kg	7.5 mg	0.073 mg
V, Maintenance, Battery	Energy	7,600 GJ	150 kJ	1.5 kJ
	GHG	580 mt GGE	12 g GGE	0.11 g GGE
	SO2	1,400 kg	29 mg	0.28 mg
	CO	7,400 kg	150 mg	1.5 mg
	NOX	1,200 kg	25 mg	0.24 mg
	VOC	970 kg	19 mg	0.19 mg
	Pb	4.0 kg	0.080 mg	0.00079 mg
	PM10	390 kg	7.8 mg	0.077 mg
V, Maintenance, Chemical Application	Energy	24,000 GJ	490 kJ	4.8 kJ
	GHG	2,200 mt GGE	44 g GGE	0.43 g GGE
	SO2	4,200 kg	84 mg	0.83 mg
	CO	6,000 kg	120 mg	1.2 mg
	NOX	2,400 kg	49 mg	0.48 mg
	VOC	2,700 kg	54 mg	0.54 mg
	Pb	-	-	-
	PM10	430 kg	8.7 mg	0.086 mg
V, Maintenance, Parts Cleaning	Energy	22,000 GJ	430 kJ	4.3 kJ
	GHG	1,900 mt GGE	37 g GGE	0.37 g GGE
	SO2	3,000 kg	60 mg	0.59 mg
	CO	7,900 kg	160 mg	1.6 mg
	NOX	2,600 kg	53 mg	0.52 mg
	VOC	3,500 kg	70 mg	0.69 mg
	Pb	-	-	-
	PM10	520 kg	11 mg	0.10 mg

(Table 57 continued on next page)

Table 57 – Midsize Aircraft Life-cycle Vehicle Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Maintenance, Metal Finishing	Energy	36,000 GJ	720 kJ	7.1 kJ
	GHG	2,100 mt GGE	42 g GGE	0.42 g GGE
	SO2	5,800 kg	120 mg	1.1 mg
	CO	5,500 kg	110 mg	1.1 mg
	NOX	2,500 kg	50 mg	0.49 mg
	VOC	1,200 kg	24 mg	0.24 mg
	Pb	-	-	-
	PM10	560 kg	11 mg	0.11 mg
V, Maintenance, Coating Application	Energy	16,000 GJ	320 kJ	3.2 kJ
	GHG	1,200 mt GGE	24 g GGE	0.23 g GGE
	SO2	2,200 kg	45 mg	0.44 mg
	CO	9,900 kg	200 mg	1.9 mg
	NOX	2,000 kg	40 mg	0.40 mg
	VOC	2,900 kg	58 mg	0.58 mg
	Pb	4.0 kg	0.080 mg	0.00079 mg
	PM10	740 kg	15 mg	0.15 mg
V, Maintenance, Depainting	Energy	36,000 GJ	720 kJ	7.1 kJ
	GHG	2,100 mt GGE	42 g GGE	0.42 g GGE
	SO2	5,800 kg	120 mg	1.1 mg
	CO	5,500 kg	110 mg	1.1 mg
	NOX	2,500 kg	50 mg	0.49 mg
	VOC	1,200 kg	24 mg	0.24 mg
	Pb	-	-	-
	PM10	560 kg	11 mg	0.11 mg
V, Maintenance, Painting	Energy	48,000 GJ	970 kJ	9.5 kJ
	GHG	3,500 mt GGE	71 g GGE	0.70 g GGE
	SO2	6,700 kg	130 mg	1.3 mg
	CO	30,000 kg	590 mg	5.8 mg
	NOX	6,000 kg	120 mg	1.2 mg
	VOC	8,800 kg	180 mg	1.7 mg
	Pb	12 kg	0.24 mg	0.0024 mg
	PM10	2,200 kg	44 mg	0.44 mg
V, Maintenance, Engine	Energy	29,000 GJ	570 kJ	5.6 kJ
	GHG	2,300 mt GGE	46 g GGE	0.45 g GGE
	SO2	6,500 kg	130 mg	1.3 mg
	CO	20,000 kg	390 mg	3.8 mg
	NOX	5,100 kg	100 mg	1.0 mg
	VOC	2,900 kg	59 mg	0.58 mg
	Pb	5.6 kg	0.11 mg	0.0011 mg
	PM10	1,400 kg	29 mg	0.28 mg
V, Insurance, Incidents	Energy	3,100 GJ	62 kJ	0.61 kJ
	GHG	250 mt GGE	5.0 g GGE	0.050 g GGE
	SO2	620 kg	12 mg	0.12 mg
	CO	2,800 kg	56 mg	0.55 mg
	NOX	700 kg	14 mg	0.14 mg
	VOC	520 kg	10 mg	0.10 mg
	Pb	-	-	-
	PM10	130 kg	2.6 mg	0.026 mg
V, Insurance, Health	Energy	14,000 GJ	280 kJ	2.8 kJ
	GHG	1,200 mt GGE	23 g GGE	0.23 g GGE
	SO2	2,800 kg	57 mg	0.56 mg
	CO	13,000 kg	260 mg	2.5 mg
	NOX	3,200 kg	64 mg	0.63 mg
	VOC	2,400 kg	47 mg	0.47 mg
	Pb	-	-	-
	PM10	600 kg	12 mg	0.12 mg

(Table 57 continued on next page)

Table 58 – Midsize Aircraft Life-cycle Infrastructure and Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Construction, Airports	Energy	5,800 GJ	120 kJ	1.1 kJ
	GHG	450 mt GGE	9.0 g GGE	0.089 g GGE
	SO2	790 kg	16 mg	0.16 mg
	CO	4,100 kg	83 mg	0.82 mg
	NOX	1,500 kg	30 mg	0.30 mg
	VOC	760 kg	15 mg	0.15 mg
	Pb	-	-	-
	PM10	310 kg	6.2 mg	0.061 mg
I, Construction, Runways	Energy	80,000 GJ	1,600 kJ	16 kJ
	GHG	7,400 mt GGE	150 g GGE	1.5 g GGE
	SO2	37,000 kg	740 mg	7.3 mg
	CO	52,000 kg	1,000 mg	10 mg
	NOX	32,000 kg	650 mg	6.4 mg
	VOC	-	-	-
	Pb	5.5 kg	0.11 mg	0.0011 mg
	PM10	6,300 kg	130 mg	1.2 mg
I, Construction, Tarmacs	Energy	210,000 GJ	4,200 kJ	41 kJ
	GHG	19,000 mt GGE	390 g GGE	3.8 g GGE
	SO2	97,000 kg	1,900 mg	19 mg
	CO	140,000 kg	2,700 mg	27 mg
	NOX	84,000 kg	1,700 mg	17 mg
	VOC	-	-	-
	Pb	14 kg	0.29 mg	0.0028 mg
	PM10	16,000 kg	330 mg	3.2 mg
I, Operation, Runway Lighting	Energy	13,000 GJ	270 kJ	2.6 kJ
	GHG	2,800 mt GGE	56 g GGE	0.55 g GGE
	SO2	14,000 kg	280 mg	2.8 mg
	CO	1,300 kg	27 mg	0.27 mg
	NOX	4,600 kg	92 mg	0.91 mg
	VOC	120 kg	2.4 mg	0.024 mg
	Pb	0.22 kg	0.0044 mg	0.000043 mg
	PM10	150 kg	3.1 mg	0.030 mg
I, Operation, Other Electricity	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
I, Operation, Deicing Fluid Production	Energy	21,000 GJ	420 kJ	4.1 kJ
	GHG	1,500 mt GGE	31 g GGE	0.31 g GGE
	SO2	6,400 kg	130 mg	1.3 mg
	CO	9,900 kg	200 mg	2.0 mg
	NOX	6,700 kg	130 mg	1.3 mg
	VOC	3,200 kg	64 mg	0.63 mg
	Pb	-	-	-
	PM10	990 kg	20 mg	0.20 mg
I, Operation, Ground Support Equipment	Energy	170,000 GJ	3,300 kJ	33 kJ
	GHG	13,000 mt GGE	250 g GGE	2.5 g GGE
	SO2	9,400 kg	190 mg	1.9 mg
	CO	920,000 kg	18,000 mg	180 mg
	NOX	130,000 kg	2,500 mg	25 mg
	VOC	34,000 kg	680 mg	6.7 mg
	Pb	-	-	-
	PM10	5,500 kg	110 mg	1.1 mg

(Table 58 continued on next page)

Table 58 – Midsize Aircraft Life-cycle Infrastructure and Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Maintenance, Airports	Energy	290 GJ	5.8 kJ	0.057 kJ
	GHG	23 mt GGE	0.45 g GGE	0.0045 g GGE
	SO2	40 kg	0.79 mg	0.0078 mg
	CO	210 kg	4.1 mg	0.041 mg
	NOX	76 kg	1.5 mg	0.015 mg
	VOC	38 kg	0.76 mg	0.0075 mg
	Pb	-	-	-
	PM10	16 kg	0.31 mg	0.0031 mg
I, Maintenance, Runways	Energy	6,400 GJ	130 kJ	1.3 kJ
	GHG	910 mt GGE	18 g GGE	0.18 g GGE
	SO2	2,200 kg	45 mg	0.44 mg
	CO	6,900 kg	140 mg	1.4 mg
	NOX	3,200 kg	64 mg	0.63 mg
	VOC	-	-	-
	Pb	0.85 kg	0.017 mg	0.00017 mg
	PM10	750 kg	15 mg	0.15 mg
I, Maintenance, Tarmacs	Energy	17,000 GJ	340 kJ	3.3 kJ
	GHG	2,400 mt GGE	48 g GGE	0.47 g GGE
	SO2	5,900 kg	120 mg	1.2 mg
	CO	18,000 kg	370 mg	3.6 mg
	NOX	8,500 kg	170 mg	1.7 mg
	VOC	-	-	-
	Pb	2.2 kg	0.045 mg	0.00044 mg
	PM10	2,000 kg	39 mg	0.39 mg
I, Parking	Energy	71,000 GJ	1,400 kJ	14 kJ
	GHG	6,800 mt GGE	140 g GGE	1.3 g GGE
	SO2	36,000 kg	730 mg	7.2 mg
	CO	49,000 kg	990 mg	9.7 mg
	NOX	29,000 kg	570 mg	5.7 mg
	VOC	-	-	-
	Pb	4.1 kg	0.083 mg	0.00082 mg
	PM10	5,300 kg	110 mg	1.0 mg
I, Insurance, Non-Operator	Energy	12,000 GJ	240 kJ	2.4 kJ
	GHG	1,000 mt GGE	20 g GGE	0.20 g GGE
	SO2	2,500 kg	49 mg	0.49 mg
	CO	11,000 kg	220 mg	2.2 mg
	NOX	2,800 kg	55 mg	0.55 mg
	VOC	2,100 kg	41 mg	0.41 mg
	Pb	-	-	-
	PM10	520 kg	10 mg	0.10 mg
I, Insurance, Liability	Energy	1,400 GJ	28 kJ	0.27 kJ
	GHG	110 mt GGE	2.3 g GGE	0.022 g GGE
	SO2	280 kg	5.5 mg	0.055 mg
	CO	1,200 kg	25 mg	0.25 mg
	NOX	310 kg	6.2 mg	0.061 mg
	VOC	230 kg	4.6 mg	0.046 mg
	Pb	-	-	-
	PM10	59 kg	1.2 mg	0.012 mg
I, Maintenance, Airports	Energy	290 GJ	5.8 kJ	0.057 kJ
	GHG	23 mt GGE	0.45 g GGE	0.0045 g GGE
	SO2	40 kg	0.79 mg	0.0078 mg
	CO	210 kg	4.1 mg	0.041 mg
	NOX	76 kg	1.5 mg	0.015 mg
	VOC	38 kg	0.76 mg	0.0075 mg
	Pb	-	-	-
	PM10	16 kg	0.31 mg	0.0031 mg
F, Refining & Distribution	Energy	1,300,000 GJ	26,000 kJ	250 kJ
	GHG	120,000 mt GGE	2,300 g GGE	23 g GGE
	SO2	220,000 kg	4,400 mg	43 mg
	CO	320,000 kg	6,400 mg	64 mg
	NOX	200,000 kg	4,100 mg	40 mg
	VOC	140,000 kg	2,800 mg	27 mg
	Pb	-	-	-
	PM10	33,000 kg	660 mg	6.5 mg

8.4 Large Aircraft Life-cycle Inventory

Table 59 – Large Aircraft Life-cycle Vehicle Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Aircraft Manufacture	Energy	650,000 GJ	43,000 kJ	140 kJ
	GHG	52,000 mt GGE	3,500 g GGE	11 g GGE
	SO2	140,000 kg	9,100 mg	30 mg
	CO	520,000 kg	35,000 mg	110 mg
	NOX	110,000 kg	7,600 mg	25 mg
	VOC	85,000 kg	5,700 mg	19 mg
	Pb	110 kg	7.6 mg	0.025 mg
	PM10	32,000 kg	2,100 mg	7.0 mg
V, Engine Manufacture	Energy	140,000 GJ	9,100 kJ	30 kJ
	GHG	11,000 mt GGE	730 g GGE	2.4 g GGE
	SO2	31,000 kg	2,100 mg	6.8 mg
	CO	93,000 kg	6,200 mg	20 mg
	NOX	24,000 kg	1,600 mg	5.3 mg
	VOC	14,000 kg	940 mg	3.1 mg
	Pb	27 kg	1.8 mg	0.0058 mg
	PM10	6,900 kg	460 mg	1.5 mg
V, Operation, APU	Energy	93,000 GJ	6,200 kJ	20 kJ
	GHG	6,200 mt GGE	410 g GGE	1.3 g GGE
	SO2	470 kg	31 mg	0.10 mg
	CO	7,800 kg	520 mg	1.7 mg
	NOX	1,500 kg	98 mg	0.32 mg
	VOC	700 kg	47 mg	0.15 mg
	Pb	-	-	-
	PM10	-	-	-
V, Operation, Startup	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	3,200 kg	210 mg	0.70 mg
	Pb	-	-	-
	PM10	-	-	-
V, Operation, Taxi	Energy	130,000 GJ	8,500 kJ	28 kJ
	GHG	8,400 mt GGE	560 g GGE	1.8 g GGE
	SO2	3,700 kg	250 mg	0.81 mg
	CO	30,000 kg	2,000 mg	6.6 mg
	NOX	14,000 kg	930 mg	3.0 mg
	VOC	1,600 kg	110 mg	0.36 mg
	Pb	-	-	-
	PM10	850 kg	57 mg	0.19 mg
V, Operation, Take Off	Energy	56,000 GJ	3,700 kJ	12 kJ
	GHG	3,700 mt GGE	250 g GGE	0.81 g GGE
	SO2	1,600 kg	110 mg	0.36 mg
	CO	130 kg	8.5 mg	0.028 mg
	NOX	40,000 kg	2,700 mg	8.7 mg
	VOC	150 kg	10 mg	0.033 mg
	Pb	-	-	-
	PM10	640 kg	43 mg	0.14 mg
V, Operation, Climb Out	Energy	140,000 GJ	9,500 kJ	31 kJ
	GHG	9,500 mt GGE	630 g GGE	2.1 g GGE
	SO2	4,100 kg	280 mg	0.91 mg
	CO	320 kg	22 mg	0.071 mg
	NOX	77,000 kg	5,100 mg	17 mg
	VOC	390 kg	26 mg	0.085 mg
	Pb	-	-	-
	PM10	1,700 kg	110 mg	0.36 mg

(Table 59 continued on next page)

Table 59 – Large Aircraft Life-cycle Vehicle Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Operation, Cruise	Energy	9,800,000 GJ	650,000 kJ	2,100 kJ
	GHG	660,000 mt GGE	44,000 g GGE	140 g GGE
	SO2	210,000 kg	14,000 mg	46 mg
	CO	200,000 kg	13,000 mg	44 mg
	NOX	2,600,000 kg	170,000 mg	570 mg
	VOC	51,000 kg	3,400 mg	11 mg
	Pb	-	-	-
	PM10	8,300 kg	560 mg	1.8 mg
V, Operation, Approach	Energy	85,000 GJ	5,700 kJ	19 kJ
	GHG	5,700 mt GGE	380 g GGE	1.2 g GGE
	SO2	2,500 kg	170 mg	0.54 mg
	CO	1,600 kg	110 mg	0.35 mg
	NOX	22,000 kg	1,400 mg	4.7 mg
	VOC	410 kg	28 mg	0.091 mg
	Pb	-	-	-
	PM10	550 kg	37 mg	0.12 mg
V, Operation, Taxi In	Energy	47,000 GJ	3,100 kJ	10 kJ
	GHG	3,100 mt GGE	210 g GGE	0.68 g GGE
	SO2	1,400 kg	91 mg	0.30 mg
	CO	11,000 kg	740 mg	2.4 mg
	NOX	5,100 kg	340 mg	1.1 mg
	VOC	600 kg	40 mg	0.13 mg
	Pb	-	-	-
	PM10	310 kg	21 mg	0.069 mg
V, Maintenance, Lubrication & Fuel	Energy	26,000 GJ	1,800 kJ	5.7 kJ
	GHG	1,700 mt GGE	110 g GGE	0.38 g GGE
	SO2	920 kg	62 mg	0.20 mg
	CO	3,100 kg	210 mg	0.67 mg
	NOX	840 kg	56 mg	0.18 mg
	VOC	780 kg	52 mg	0.17 mg
	Pb	-	-	-
	PM10	160 kg	11 mg	0.035 mg
V, Maintenance, Battery	Energy	3,300 GJ	220 kJ	0.71 kJ
	GHG	250 mt GGE	17 g GGE	0.055 g GGE
	SO2	620 kg	41 mg	0.14 mg
	CO	3,200 kg	210 mg	0.70 mg
	NOX	530 kg	35 mg	0.12 mg
	VOC	420 kg	28 mg	0.091 mg
	Pb	1.7 kg	0.11 mg	0.00038 mg
	PM10	170 kg	11 mg	0.037 mg
V, Maintenance, Chemical Application	Energy	11,000 GJ	700 kJ	2.3 kJ
	GHG	940 mt GGE	63 g GGE	0.21 g GGE
	SO2	1,800 kg	120 mg	0.40 mg
	CO	2,600 kg	170 mg	0.56 mg
	NOX	1,100 kg	70 mg	0.23 mg
	VOC	1,200 kg	78 mg	0.26 mg
	Pb	-	-	-
	PM10	190 kg	12 mg	0.041 mg
V, Maintenance, Parts Cleaning	Energy	9,300 GJ	620 kJ	2.0 kJ
	GHG	810 mt GGE	54 g GGE	0.18 g GGE
	SO2	1,300 kg	86 mg	0.28 mg
	CO	3,400 kg	230 mg	0.74 mg
	NOX	1,100 kg	76 mg	0.25 mg
	VOC	1,500 kg	100 mg	0.33 mg
	Pb	-	-	-
	PM10	230 kg	15 mg	0.049 mg

(Table 59 continued on next page)

Table 59 – Large Aircraft Life-cycle Vehicle Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
V, Maintenance, Metal Finishing	Energy	15,000 GJ	1,000 kJ	3.4 kJ
	GHG	910 mt GGE	61 g GGE	0.20 g GGE
	SO2	2,500 kg	170 mg	0.55 mg
	CO	2,400 kg	160 mg	0.52 mg
	NOX	1,100 kg	72 mg	0.24 mg
	VOC	520 kg	35 mg	0.11 mg
	Pb	-	-	-
	PM10	240 kg	16 mg	0.053 mg
V, Maintenance, Coating Application	Energy	6,900 GJ	460 kJ	1.5 kJ
	GHG	510 mt GGE	34 g GGE	0.11 g GGE
	SO2	960 kg	64 mg	0.21 mg
	CO	4,200 kg	280 mg	0.93 mg
	NOX	870 kg	58 mg	0.19 mg
	VOC	1,300 kg	84 mg	0.27 mg
	Pb	1.7 kg	0.11 mg	0.00038 mg
	PM10	320 kg	21 mg	0.069 mg
V, Maintenance, Depainting	Energy	15,000 GJ	1,000 kJ	3.4 kJ
	GHG	910 mt GGE	61 g GGE	0.20 g GGE
	SO2	2,500 kg	170 mg	0.55 mg
	CO	2,400 kg	160 mg	0.52 mg
	NOX	1,100 kg	72 mg	0.24 mg
	VOC	520 kg	35 mg	0.11 mg
	Pb	-	-	-
	PM10	240 kg	16 mg	0.053 mg
V, Maintenance, Painting	Energy	21,000 GJ	1,400 kJ	4.6 kJ
	GHG	1,500 mt GGE	100 g GGE	0.33 g GGE
	SO2	2,900 kg	190 mg	0.63 mg
	CO	13,000 kg	850 mg	2.8 mg
	NOX	2,600 kg	170 mg	0.57 mg
	VOC	3,800 kg	250 mg	0.82 mg
	Pb	5.1 kg	0.34 mg	0.0011 mg
	PM10	950 kg	64 mg	0.21 mg
V, Maintenance, Engine	Energy	63,000 GJ	4,200 kJ	14 kJ
	GHG	5,000 mt GGE	340 g GGE	1.1 g GGE
	SO2	14,000 kg	950 mg	3.1 mg
	CO	43,000 kg	2,900 mg	9.4 mg
	NOX	11,000 kg	750 mg	2.4 mg
	VOC	6,400 kg	430 mg	1.4 mg
	Pb	12 kg	0.82 mg	0.0027 mg
	PM10	3,200 kg	210 mg	0.69 mg
V, Insurance, Incidents	Energy	770 GJ	51 kJ	0.17 kJ
	GHG	63 mt GGE	4.2 g GGE	0.014 g GGE
	SO2	150 kg	10 mg	0.034 mg
	CO	700 kg	47 mg	0.15 mg
	NOX	170 kg	12 mg	0.038 mg
	VOC	130 kg	8.6 mg	0.028 mg
	Pb	-	-	-
	PM10	33 kg	2.2 mg	0.0072 mg
V, Insurance, Health	Energy	8,500 GJ	570 kJ	1.9 kJ
	GHG	690 mt GGE	46 g GGE	0.15 g GGE
	SO2	1,700 kg	110 mg	0.37 mg
	CO	7,700 kg	510 mg	1.7 mg
	NOX	1,900 kg	130 mg	0.42 mg
	VOC	1,400 kg	95 mg	0.31 mg
	Pb	-	-	-
	PM10	360 kg	24 mg	0.079 mg

(Table 59 continued on next page)

Table 60 – Large Aircraft Life-cycle Infrastructure and Fuels Inventory

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Construction, Airports	Energy	5,200 GJ	350 kJ	1.1 kJ
	GHG	410 mt GGE	27 g GGE	0.089 g GGE
	SO2	710 kg	48 mg	0.16 mg
	CO	3,700 kg	250 mg	0.82 mg
	NOX	1,400 kg	91 mg	0.30 mg
	VOC	690 kg	46 mg	0.15 mg
	Pb	-	-	-
	PM10	280 kg	19 mg	0.061 mg
I, Construction, Runways	Energy	61,000 GJ	4,100 kJ	13 kJ
	GHG	5,700 mt GGE	380 g GGE	1.2 g GGE
	SO2	28,000 kg	1,900 mg	6.2 mg
	CO	40,000 kg	2,700 mg	8.8 mg
	NOX	25,000 kg	1,700 mg	5.4 mg
	VOC	-	-	-
	Pb	4.2 kg	0.28 mg	0.00092 mg
	PM10	4,800 kg	320 mg	1.1 mg
I, Construction, Tarmacs	Energy	160,000 GJ	11,000 kJ	35 kJ
	GHG	15,000 mt GGE	1,000 g GGE	3.3 g GGE
	SO2	75,000 kg	5,000 mg	16 mg
	CO	110,000 kg	7,100 mg	23 mg
	NOX	65,000 kg	4,300 mg	14 mg
	VOC	-	-	-
	Pb	11 kg	0.74 mg	0.0024 mg
	PM10	13,000 kg	850 mg	2.8 mg
I, Operation, Runway Lighting	Energy	10,000 GJ	680 kJ	2.2 kJ
	GHG	2,100 mt GGE	140 g GGE	0.47 g GGE
	SO2	11,000 kg	720 mg	2.4 mg
	CO	1,000 kg	69 mg	0.23 mg
	NOX	3,500 kg	240 mg	0.78 mg
	VOC	92 kg	6.1 mg	0.020 mg
	Pb	0.17 kg	0.011 mg	0.000037 mg
	PM10	120 kg	7.9 mg	0.026 mg
I, Operation, Other Electricity	Energy	-	-	-
	GHG	-	-	-
	SO2	-	-	-
	CO	-	-	-
	NOX	-	-	-
	VOC	-	-	-
	Pb	-	-	-
	PM10	-	-	-
I, Operation, Deicing Fluid Production	Energy	16,000 GJ	1,100 kJ	3.5 kJ
	GHG	1,200 mt GGE	80 g GGE	0.26 g GGE
	SO2	4,900 kg	330 mg	1.1 mg
	CO	7,600 kg	510 mg	1.7 mg
	NOX	5,100 kg	340 mg	1.1 mg
	VOC	2,400 kg	160 mg	0.53 mg
	Pb	-	-	-
	PM10	760 kg	51 mg	0.17 mg
I, Operation, Ground Support Equipment	Energy	130,000 GJ	8,500 kJ	28 kJ
	GHG	9,700 mt GGE	650 g GGE	2.1 g GGE
	SO2	7,200 kg	480 mg	1.6 mg
	CO	710,000 kg	47,000 mg	150 mg
	NOX	98,000 kg	6,500 mg	21 mg
	VOC	26,000 kg	1,700 mg	5.7 mg
	Pb	-	-	-
	PM10	4,300 kg	280 mg	0.93 mg

(Table 60 continued on next page)

Table 60 – Large Aircraft Life-cycle Infrastructure and Fuels Inventory (continued)

Life-Cycle Component	I/O	per Vehicle-Life	per VMT	per PMT
I, Maintenance, Airports	Energy	260 GJ	18 kJ	0.057 kJ
	GHG	20 mt GGE	1.4 g GGE	0.0045 g GGE
	SO2	36 kg	2.4 mg	0.0078 mg
	CO	190 kg	12 mg	0.041 mg
	NOX	68 kg	4.6 mg	0.015 mg
	VOC	34 kg	2.3 mg	0.0075 mg
	Pb	-	-	-
	PM10	14 kg	0.94 mg	0.0031 mg
I, Maintenance, Runways	Energy	4,900 GJ	330 kJ	1.1 kJ
	GHG	700 mt GGE	47 g GGE	0.15 g GGE
	SO2	1,700 kg	120 mg	0.38 mg
	CO	5,300 kg	360 mg	1.2 mg
	NOX	2,500 kg	170 mg	0.54 mg
	VOC	-	-	-
	Pb	0.65 kg	0.044 mg	0.00014 mg
	PM10	580 kg	39 mg	0.13 mg
I, Maintenance, Tarmacs	Energy	13,000 GJ	860 kJ	2.8 kJ
	GHG	1,800 mt GGE	120 g GGE	0.40 g GGE
	SO2	4,500 kg	300 mg	1.00 mg
	CO	14,000 kg	940 mg	3.1 mg
	NOX	6,500 kg	430 mg	1.4 mg
	VOC	-	-	-
	Pb	1.7 kg	0.11 mg	0.00038 mg
	PM10	1,500 kg	100 mg	0.33 mg
I, Parking	Energy	64,000 GJ	4,300 kJ	14 kJ
	GHG	6,100 mt GGE	410 g GGE	1.3 g GGE
	SO2	33,000 kg	2,200 mg	7.2 mg
	CO	44,000 kg	3,000 mg	9.7 mg
	NOX	26,000 kg	1,700 mg	5.7 mg
	VOC	-	-	-
	Pb	3.7 kg	0.25 mg	0.00082 mg
	PM10	4,800 kg	320 mg	1.0 mg
I, Insurance, Non-Operator	Energy	9,400 GJ	630 kJ	2.1 kJ
	GHG	770 mt GGE	52 g GGE	0.17 g GGE
	SO2	1,900 kg	130 mg	0.41 mg
	CO	8,500 kg	570 mg	1.9 mg
	NOX	2,100 kg	140 mg	0.47 mg
	VOC	1,600 kg	110 mg	0.35 mg
	Pb	-	-	-
	PM10	400 kg	27 mg	0.088 mg
I, Insurance, Liability	Energy	1,100 GJ	71 kJ	0.23 kJ
	GHG	87 mt GGE	5.8 g GGE	0.019 g GGE
	SO2	210 kg	14 mg	0.047 mg
	CO	960 kg	64 mg	0.21 mg
	NOX	240 kg	16 mg	0.052 mg
	VOC	180 kg	12 mg	0.039 mg
	Pb	-	-	-
	PM10	45 kg	3.0 mg	0.0099 mg
I, Maintenance, Airports	Energy	260 GJ	18 kJ	0.057 kJ
	GHG	20 mt GGE	1.4 g GGE	0.0045 g GGE
	SO2	36 kg	2.4 mg	0.0078 mg
	CO	190 kg	12 mg	0.041 mg
	NOX	68 kg	4.6 mg	0.015 mg
	VOC	34 kg	2.3 mg	0.0075 mg
	Pb	-	-	-
	PM10	14 kg	0.94 mg	0.0031 mg
F, Refining & Distribution	Energy	1,000,000 GJ	68,000 kJ	220 kJ
	GHG	92,000 mt GGE	6,200 g GGE	20 g GGE
	SO2	170,000 kg	12,000 mg	38 mg
	CO	250,000 kg	17,000 mg	56 mg
	NOX	160,000 kg	11,000 mg	35 mg
	VOC	110,000 kg	7,300 mg	24 mg
	Pb	-	-	-
	PM10	26,000 kg	1,700 mg	5.7 mg

9 Model Background

In an effort to continually improve the environmental inventory originally reported in Chester (2009), background models are periodically updated with improved methodology and data based on feedback. The model versions used in Chester (2009) are 20080814/compiled, 20080724/onroad, 20080805/rail, and 20080714/air. The model versions used in this assessment are 20090304/compiled, 20090304/onroad, 20090304/rail, and 20080814/air. This document is prepared from the file "lci_other_modes_05.docx."