PORT OF VIRGINIA
2023 EMISSIONS INVENTORY
CARGO HANDLING EQUIPMENT AND VEHICLES

THE PORT OF VIRGINIA®

Prepared by:

STARCREST CONSULTING GROUP, LLC
ENVIRONMENTAL MANAGEMENT • AIR QUALITY • CLIMATE • SUSTAINABILITY

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ACRONYMS AND ABBREVIATIONS

CHE	cargo handling equipment
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
D	distance
DPM	diesel particulate matter
E	emissions
EF	emission factor
EPA	U.S. Environmental Protection Agency
FCF	fuel correction factor
g/bhp-hr	grams per brake horsepower-hour
g/hr	grams per hour
g/kW-hr	grams per kilowatt-hour
g/mi	grams per mile
GHG	greenhouse gas
GWP	global warming potential
HC	hydrocarbons
hp	horsepower
hrs	hours
kW	kilowatt
kWh	kilowatt hour
lbs	pounds
LF	load factor
LSI	large spark ignition
mph	miles per hour
MOVES	Motor Vehicle Emissions Simulator, EPA model
MT	metric tons
MWh	megawatt hour
N_2O	nitrous oxide
NOx	oxides of nitrogen
NIT	Norfolk International Terminals
NNMT	Newport News Marine Terminal
OGV	ocean-going vessel
PMT	Portsmouth Marine Terminal
PM	particulate matter
PM_{10}	particulate matter less than 10 microns in diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
RECs	renewable energy certificates
RoRo	roll on/roll off
RMT	Richmond Marine Terminal
S	sulfur
SCC	source classification code

SO_2	Sulfur dioxide
tons	Short tons
tonnes	metric tons
tpy	tons per year
U.S.	United States
ULSD	ultra-low sulfur diesel
VIG	Virginia International Gateway
VIP	Virginia Inland Port
VOC	volatile organic compound

SECTION 1 INTRODUCTION

The Port of Virginia developed the 2023 Emissions Inventory of cargo handling equipment and light to medium duty vehicles operating at the Port. This inventory, based on 2023 calendar year activity, includes the tail pipe emissions for the port owned equipment and vehicles and also the scope 2 GHG emissions based on electricity consumption.

1.1 Port Overview

The Port of Virginia, with a deep-water harbor, is the second largest port on the East Coast by tonnage and the third largest by container volume. The Port of Virginia is an economic engine for Virginia and is within 2 days of 75% of the U.S. consumers. The main cargo is container, breakbulk and roll-on/roll-off (RoRo) cargo such as heavy equipment, machinery and vehicles.

The following facilities were included in this inventory:

- ✓ Norfolk International Terminals (NIT) - container
- ✓ Virginia International Gateway (VIG) - container
- ✓ Newport News Marine Terminal (NNMT) – breakbulk and RoRo
- ✓ Portsmouth Marine Terminal (PMT) – breakbulk and offshore wind hub
- ✓ Richmond Marine Terminal (RMT) – container, general cargo, barge service
- ✓ Virginia Inland Port (VIP) – intermodal container transport facility

Figure 1.1 is an aerial photo of the main marine terminals located at the Port of Virginia.

Figure 1.1: Aerial Photo of Port of Virginia

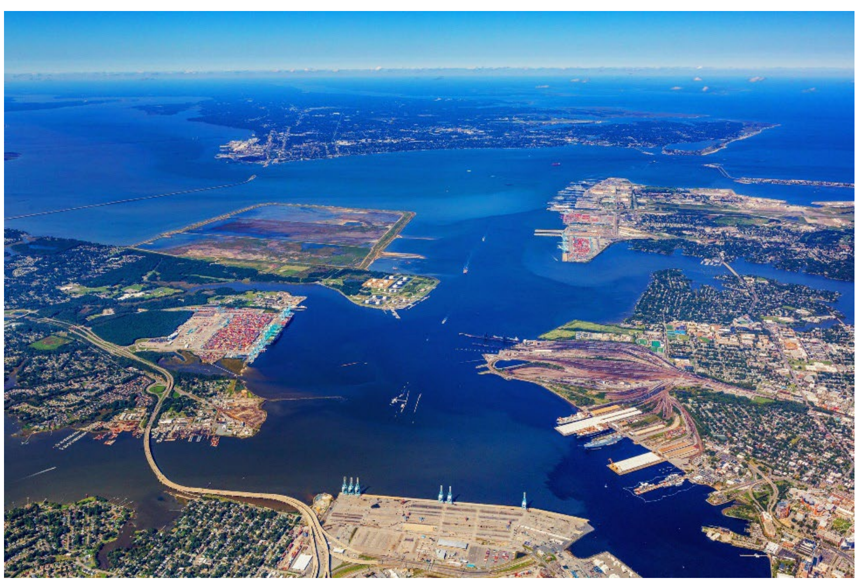

Figure 1.2 shows NIT, the port's largest container terminal with semi-automated stacking cranes.

Figure 1.2: Norfolk International Terminals (NIT)

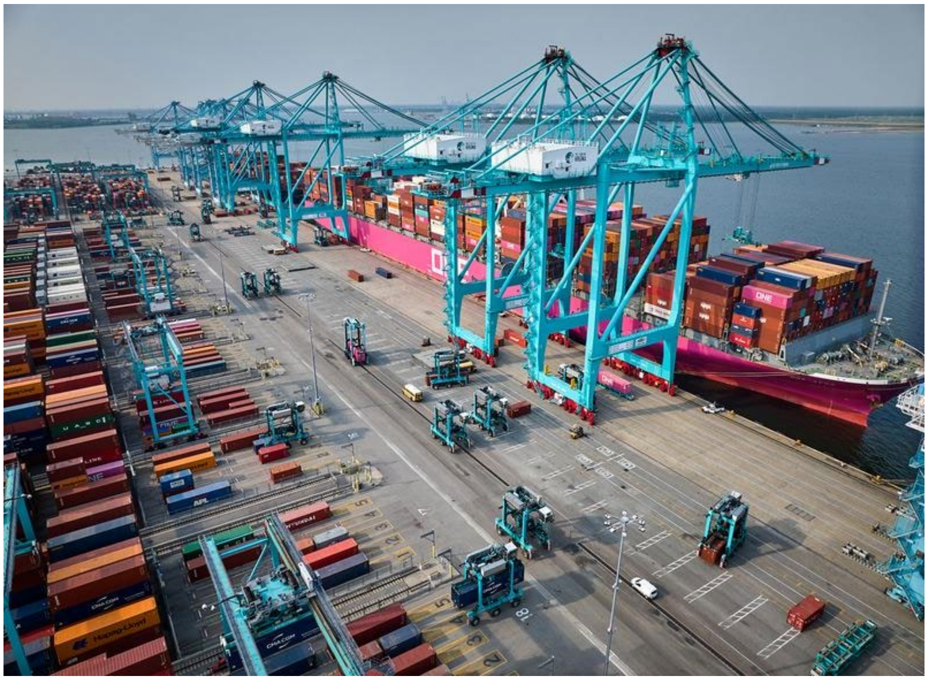

Figure 1.3 shows VIG, the second largest container terminal at the Port.

Figure 1.3: Virginia International Gateway (VIG)

Figure 1.4 shows Newport News Marine Terminal, a breakbulk and RoRo facility with outside and covered storage space.

Figure 1.4: Newport News Marine Terminal (NNMT)

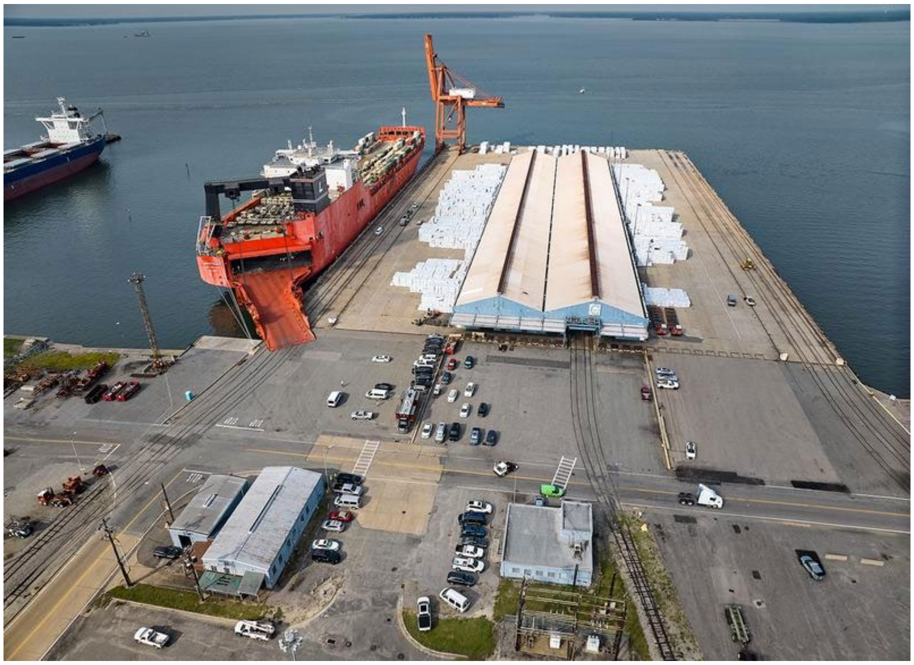

Figure 1.5 shows Richmond Marine Terminal which serves as a streamlined service between ocean and inland terminal connections through dedicated barge service.

Figure 1.5: Richmond Marine Terminal (RMT)

Figure 1.6 shows Virginia Inland Port, an intermodal container transport facility, that brings cargo 200 miles inland via rail.

Figure 1.6: Virginia Inland Port (VIP)

1.2 Scope of Study

The scope of the study is described in terms of the pollutants estimated, the source categories included, and the geographical domain. The activity year for this study is 2023 calendar year. The geographical domain for the on-terminal equipment and vehicles are within the marine facilities.

Exhaust emissions of the following pollutants are estimated:

- Criteria pollutants, surrogates, and precursors:
  - Oxides of nitrogen (NO_x)
  - Particulate matter (PM) (10-micron, 2.5-micron)
  - Volatile organic compounds (VOC)
  - Carbon monoxide (CO)
  - Sulfur dioxide (SO_2)
- Diesel particulate matter (DPM)

- Fuel combustion-related greenhouse gas (GHG) and carbon dioxide equivalents (CO_2e):
  - Carbon dioxide (CO_2)
  - Nitrous oxide (N_2O)
  - Methane (CH_4)

The GHG emission estimates are multiplied by their respective global warming potentials (GWP) [1] of 1 for CO_2, 265 for N_2O and 28 for CH_4 and summed to obtain the resulting CO_2e emissions.

[1]See*: www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-annex-6-additional-information.pdf, Annex 6, Table A-233*

Table 1.1 provides a description of the pollutants, greenhouse gases, and ozone.

Table 1.1: Pollutant and Greenhouse Gases Description

Pollutant	Sources	Health & Environmental Effects
Oxides of nitrogen (NO_x) is the generic term for a group of highly reactive gases; all of which contain nitrogen and oxygen in varying amounts. Most NO_x is colorless and odorless.	NO_x forms when fuel is burned at high temperatures, as in a combustion process. The primary manmade sources of NO_x are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.	NO_x can react with other compounds in the air to form tiny particles adding to PM concentrations. NO_x is an ozone precursor and is also associated with respiratory health effects.
Particulate matter (PM) refers to tiny, discrete solid or aerosol particles in the air. Dust, dirt, soot, and smoke are considered particulate matter. Two types of PM are included in this emissions inventory: **PM_{10}**, which consists of particles measuring up to 10 micrometers in diameter; and **$PM_{2.5}$**, which consists of fine particles measuring 2.5 micrometers in diameter or smaller.	Vehicle exhaust (cars, trucks, buses, among others) are the predominant sources of fine particles in urban areas. In rural areas, land-clearing burning and backyard burning of yard waste contribute to particulate matter levels.	Fine particles are a concern because their very tiny size allows them travel more deeply into lungs, increasing the potential for health risks. Exposure to $PM_{2.5}$ is linked with respiratory disease, decreased lung function, asthma attacks, heart attacks and premature death.
Volatile organic compounds (VOC) are included in the emissions inventory because they are an ozone ingredient.	VOCs come from the transportation sector: cars and light trucks, marine vessels, and heavy-duty diesel vehicles.	In addition to contributing to the formation of ozone, some VOCs are air toxics which can contribute to a wide range of adverse health effects.
Carbon monoxide (CO) is a colorless, odorless, toxic gas commonly formed when carbon-containing fuel is not burned completely.	CO forms during incomplete combustion of fuels. The majority of CO comes from on and off-road vehicle engine exhaust.	CO combines with hemoglobin in red blood cells and decreases the oxygen-carrying capacity of the blood. CO weakens heart contractions, reducing the amount of blood pumped through the body. It can affect brain and lung function.

Table 1.1: Pollutant and Greenhouse Gases Description (cont'd)

Pollutant	Sources	Health & Environmental Effects
Sulfur dioxide (SO_2) is a colorless, corrosive gas produced by burning fuel containing sulfur, such as coal and oil, and by industrial processes such as smelters, paper mills, power plants and steel manufacturing plants.	SO_2 emissions are primarily a result of combustion fuels in cars, trucks, vessels, locomotives and equipment. Over the past decade, levels of sulfur in diesel and gasoline fuels have decreased dramatically due to federal regulations set by the EPA, which resulted in decreasing SO_2 emissions.	SO_2 is associated with a variety of respiratory diseases. Inhalation of SO_2 can cause increased airway resistance by constricting lung passages. Some of the SO_2 become sulfate particles in the atmosphere adding to measured PM levels.
Diesel particulate matter (DPM) is a significant component of PM. Diesel exhaust also includes more than 40 substances that are listed as hazardous pollutants. Because of their microscopic size, DPM can become trapped in the small airways of the lungs.	Sources of diesel emissions include diesel-powered trucks, buses and cars (on-road sources); diesel-powered marine vessels, construction equipment, trains and aircraft support equipment (non-road sources).	DPM is linked with health effects typical of all PM, including heart problems, aggravated asthma, chronic bronchitis and premature death.
Greenhouse gases (GHG) included in this emissions inventory are carbon dioxide, methane, and nitrous oxide. Other gases that are not significantly emitted by maritime-related sources or included in this inventory also contribute to climate change.	Both natural processes and human activities are a source of GHG. Increases of human made GHG are most responsible for disrupting the balance of the atmosphere. Transportation and electricity generation are a major source of GHG.	Climate change, also referred to as global warming, occurs when excessive amounts of GHG accumulate in our atmosphere. These gases trap heat and are thought to cause the temperature of the earth to rise.

SECTION 2 SUMMARY RESULTS

The Port of Virginia 2023 Air Emissions Inventory presents an overview of scope 1 emissions[2] produced as a result of operation of the fossil fueled port-owned cargo handling equipment (CHE) and light to medium duty vehicles (vehicles) and scope 2 emissions from electricity consumption. In 2023, the Port of Virginia's total cargo volume was 3.3 million TEUs. The throughput is included as a reference for future emissions comparisons to be able to discuss the changes in terms of cargo throughput, equipment/vehicle activity and emission reduction strategies which all have an impact on emissions.

Table 2.1 summarizes the tailpipe emissions for the fossil fueled CHE and vehicles owned and operated by the Port of Virginia marine terminals. These emissions are considered the scope 1 emissions. The emissions provided below follow the activity-based methodology using activity in hours of use and/or miles driven with EPA emissions factors and load factors.

Table 2.1: 2023 CHE and Vehicle Emissions Summary, tons and tonnes

Emissions Source	Count	NO_x tons	PM_{10} tons	$PM_{2.5}$ tons	VOC tons	CO tons	SO_2 tons	CO_2e tons	CO_2e tonnes
CHE	444	63	3.9	3.8	6.1	48	0.06	22,103	20,052
Vehicles	640	10	0.5	0.4	1.5	38	0.02	3,928	3,563
Total	**1,084**	**73**	**4.3**	**4.2**	**7.6**	**86**	**0.08**	**26,031**	**23,615**

In 2023, 88% of the Port's electricity consumption came from clean energy sources. Table 2.2 summarizes the scope 2 emissions calculated using electricity consumption provided by the Port and location and market-based emission factors that are specific to the Port's energy provider, Dominion Energy. The GHG emissions are provided in metric tons (tonnes). The location-based emissions include emissions from all sources without considering renewable energy certificates (RECs) or premium green purchase agreements. The market-based emissions include the sales and retirements of renewable energy certificates (RECs) and the purchase of renewable electricity, thus the lower Scope 2 emissions. Section 5 provides a description of the emissions methodology and emission factors used.

Table 2.2: 2023 Scope 2 Emissions Summary, tonnes

Year	Electricity Consumption kWh	Location-based CO_2e tonnes	Market-based CO_2e tonnes
2023	113,578,712	31,332	3,581

[2]See: *www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance*

SECTION 3 CARGO HANDLING EQUIPMENT

This section includes emission estimates for non-road cargo handling equipment, a term used for equipment that moves cargo, products, and supplies; material handling equipment; and other equipment that is essential to port facility operations.

Figure 3.1: Yard Tractors and Shuttle Trucks

3.1 Operational Profiles

The equipment data was provided by the Port. In 2023, 29% of the equipment are battery or grid electric, while the remainder 46% are diesel, 16% are hybrid, and 9% are propane or gasoline equipment.

Figure 3.2: Equipment Distribution by Engine Type

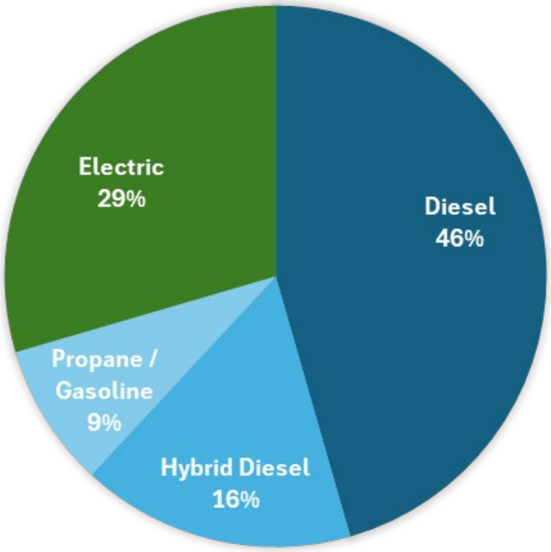

Table 3.1 summarizes the engine characteristics and operating hours of yard equipment operating at the Port in 2023. Averages of the model year, horsepower, or operating hours are used as default values when equipment specific data is not available. The "na" in the tables means that data was not available or applicable. The electric equipment is included for equipment count purposes only. Only tailpipe emissions from the fossil fueled equipment are included in the emissions tables.

Table 3.1: CHE Count and Characteristics

Equipment Type	Count	Model Year Average	Horsepower Average	Hours Average
Diesel				
Yard tractor	152	2017	158	1,909
Hybrid shuttle trucks	103	2020	103	2,200
Forklift	62	2000	114	500
Empty handler	25	2013	218	1,553
Straddle carrier	18	2006	475	1,000
Reach stacker	11	2014	286	2,393
RTG crane	8	2007	600	838
Top handler	8	2017	355	1,303
Shuttle trucks	3	2006	400	2,200
Diesel Count Total	**390**			
Propane and Gasoline				
Forklift	54	2005	77	500
Electric				
ASCs	116	na	na	na
Ship to Shore cranes	30	na	na	na
Forklift	20	na	na	na
Grunts	12	na	na	na
Yard tractor	4	na	na	na
RMGs	4	na	na	na
Electric Count Total	**186**			
Total	**630**			

Table 3.2 lists the nonroad diesel engine Tiers by equipment type for 2023. It shows the majority of the equipment have newer and cleaner engines with 79% of the diesel equipment having a Tier 3 or Tier 4 engine.

Table 3.2: Nonroad CHE Diesel Engine Tiers

Equipment	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4i	Tier 4f	Total Diesel Engines
Yard Tractor	1	9	0	0	44	98	152
Hybrid Shuttle Carrier	0	0	0	0	0	103	103
Forklift	54	2	4	0	0	2	62
Empty Handler	0	0	5	5	0	15	25
Straddle Carrier	2	0	1	15	0	0	18
Reach Stacker	0	1	2	2	0	6	11
RTG Crane	0	0	2	6	0	0	8
Top Handler	0	0	0	0	0	8	8
Shuttle Carrier	0	0	0	3	0	0	3
Total	**57**	**12**	**14**	**31**	**44**	**232**	**390**
Percent of Diesel Equipment	15%	3%	4%	8%	11%	59%	

3.2 Emissions Estimation Methodology

Emissions were estimated using the MOVES4 emission estimating model.[3] The model was designed to accommodate a wide range of off-road equipment types and recognize a defined list of equipment designations. The pieces of terminal equipment were matched with equipment types recognized by the model. The equipment collected was categorized into the most closely corresponding MOVES4/NONROAD equipment type which presents equipment types by Source Classification Code (SCC), load factor, and category common name.

The general form of the equation used for estimating equipment emissions is:

Equation 1

$$\boldsymbol{E = Power \times Activity \times LF \times EF}$$

Where:

E = emissions, grams or tons or tonnes/year
Power = rated power of the engine, hp or kW
Activity = equipment's engine operating time, hr/year
LF = load factor (ratio of average load used during normal operations as compared to full load at maximum rated horsepower; it is an estimate of the average percentage of an engine's rated power output that is required to perform its operating tasks), dimensionless
EF = emission factor by equipment type obtained by running the NONROAD module of MOVES4, grams of pollutant per unit of work, g/hp-hr or g/kW-hr

For each calendar year, MOVES4/NONROAD can be run by state/county to output emissions factors in grams/hp-hr by fuel type, equipment types, by horsepower groups and model year. These emission factors represent the average emissions in grams/hp-hr that takes into account the characteristic of the non-road fuel available in that year and the change in engine emission (in general increase in emissions) as the engine parts get older and less efficient. The horsepower groups are aligned with EPA's non-road equipment emissions standards.

Per equation 5.1 above, CHE emissions in tons per year from each piece of equipment were calculated using model year, horsepower rating, annual hours of operation information collected for port operation, equipment-specific load factor assumptions described above and MOVES4/NONROAD emission factors output. MOVES4/NONROAD was run with default conditions to obtain emission factors in grams/hp-hr. ULSD fuel with a sulfur content of 15 ppm was used for diesel equipment.

[3] See: *www.epa.gov/otaq/models/moves/*

3.3 Emission Estimates

Table 3.3 presents the estimated equipment emissions by equipment type and engine type. The engine types are diesel and large spark ignition (LSI). LSI engines include 51 propane forklifts and 3 gasoline forklifts. The diesel equipment were sorted from highest equipment count to lowest.

Table 3.3: CHE Emissions by Equipment and Engine Type, tons and tonnes

Equipment	Engine Type	Count	NO_x tons	PM_{10} tons	$PM_{2.5}$ tons	VOC tons	CO tons	SO_2 tons	CO_2e tons	CO_2e tonnes
Yard Tractor	Diesel	152	19.0	1.0	0.9	0.6	5.5	0.03	10,652	9,663
Hybrid Shuttle Carrier	Diesel	103	1.1	0.1	0.1	0.1	0.4	0.01	3,408	3,091
Forklift	Diesel	62	17.4	1.0	1.0	1.7	8.3	0.00	1,293	1,173
Empty Handler	Diesel	25	3.0	0.2	0.2	0.5	1.5	0.00	1,236	1,121
Straddle Carrier	Diesel	18	7.6	0.8	0.7	1.1	5.6	0.00	1,247	1,131
Reach Stacker	Diesel	11	3.6	0.2	0.2	0.3	0.9	0.01	1,886	1,711
RTG Crane	Diesel	8	3.5	0.3	0.3	0.4	2.2	0.00	587	533
Top Handler	Diesel	8	0.7	0.0	0.0	0.1	0.2	0.00	937	850
Shuttle Carrier	Diesel	3	2.1	0.2	0.2	0.3	1.4	0.00	385	350
Forklift	LSI	54	4.8	0.0	0.0	1.1	21.9	0.00	472	428
Total		**444**	**62.9**	**3.9**	**3.8**	**6.1**	**47.9**	**0.06**	**22,103**	**20,052**

Table 3.4 summarized the emissions by terminal and sorted from highest NOx emissions to lowest. The Norfolk International Terminals (NIT) have the most equipment and also the highest emissions for Port of Virginia. The terminal emissions were sorted from highest NOx emissions to lowest which also coincide with highest equipment count to lowest.

Table 3.4: CHE Emissions by Terminal, tons and tonnes

Terminal	Count	NO_x tons	PM_{10} tons	$PM_{2.5}$ tons	VOC tons	CO tons	SO_2 tons	CO_2e tons	CO_2e tonnes
Norfolk International Terminals	218	28.2	1.9	1.8	2.7	21.6	0.03	11,920	10,814
Virginia International Gateway	130	15.5	0.8	0.8	1.5	14.8	0.02	6,025	5,466
Portsmouth Marine Terminal	51	7.9	0.4	0.4	0.7	4.2	0.01	2,186	1,983
Virginia Inland Port	22	5.5	0.4	0.4	0.7	4.6	0.0	724	656
Newport News Mrine Terminal	13	4.9	0.3	0.3	0.4	2.3	0.00	435	394
Richmond Marine Terminal	10	1.0	0.1	0.1	0.1	0.4	0.00	813	738
Total	**444**	**62.9**	**3.9**	**3.8**	**6.1**	**47.9**	**0.06**	**22,103**	**20,052**

Table 3.5 shows the equipment energy consumption (kWh) by engine Tier for the diesel fueled equipment. It shows that 88% of the energy consumption is from cleaner engines, meaning less emissions due to the use of cleaner equipment to move the cargo. The propane and gasoline equipment kWh are listed as propane in the table.

Table 3.5: CHE Energy Consumption by Engine Tier

Engine Type	Engine Tier	Energy Consumption kWh	Percent Total
Diesel	Tier 0	1,923,477	5.5%
Diesel	Tier 1	736,869	2.1%
Diesel	Tier 2	1,099,914	3.1%
Diesel	Tier 3	3,450,251	9.8%
Diesel	Tier 4i	5,208,431	14.8%
Diesel	Tier 4f	22,214,580	63.0%
Propane		647,100	1.8%
Total		**35,280,621**	

SECTION 4 VEHICLES

This section includes emission estimates for light duty to medium duty vehicles used at the Port of Virginia terminals. This does not include the heavy-duty trucks that call the facilities.

4.1 Operational Profiles

The vehicle data was provided by the Port. Table 4.1 summarizes the types of vehicles, the counts and the average model year by engine type (diesel and gasoline). Most of the vehicles (78%) are gasoline powered, followed by diesel. The vehicles travel at an average speed of 15 miles per hour (mph). The estimated average activity is 2,500 miles per year for the trucks and buses and 15,000 miles per year for passenger cars based on an average of 1,000 hours per year per vehicle.

Table 4.1: Vehicle Types and Counts by Engine Type

Vehicle Type	Count	Model Year Average	Vehicle Miles Average
Diesel			
Light Commercial Truck	54	2004	2,500
Passenger Car	1	2017	15,000
Passenger Truck	52	2006	2,500
Transit Bus	31	2009	2,500
Gasoline			
Light Commercial Truck	90	2011	2,500
Passenger Car	104	2021	15,000
Passenger Truck	299	2015	2,500
Transit Bus	9	2011	2,500
Total	**640**		

4.2 Emissions Estimation Methodology

The latest MOVES4 model was used to calculate emission factors for on-road vehicles. The general form of the equation for estimating emissions is:

Equation 1

$$E = (EF \times A)$$

Where:
E = mass of emissions per defined period
EF = emission factor (g/mile or g/hr)
A = activity (miles driven or hours of idling during the defined period)

The model was run by model year for gasoline and diesel fuels for various vehicle types (passenger car, passenger truck, light commercial truck, and transit bus). Emission factors were developed for 15-mph travel. The vehicles reported in the fleet vehicles category were classified by fuel type and as one of these vehicle types. Emission factors by model year, fuel type, speed, and vehicle type were matched to the model year of each discrete vehicle in the dataset. Emissions were estimated by multiplying the miles driven on each terminal by the relevant emission factor, matched for vehicle type, fuel, model year, and speed based on the reported information.

4.3 Emission Estimates

Table 4.2 presents the estimated vehicle emissions by engine type for 2023.

Table 4.2: Vehicle Emissions by Engine Type, tons and tonnes

Engine Type	Count	NO_x tons	PM_{10} tons	$PM_{2.5}$ tons	VOC tons	CO tons	SO_2 tons	CO_2e tons	CO_2e tonnes
Diesel	138	9	0.4	0.4	0.8	7	0.01	1,633	1,482
Gasoline	502	1	0.0	0.0	0.7	31	0.01	2,294	2,081
Total	**640**	**10**	**0.5**	**0.4**	**1.5**	**38**	**0.02**	**3,928**	**3,563**

SECTION 5 ELECTRICITY CONSUMPTION

This section includes emission estimates for scope 2 indirect emissions associated with the generation of purchased electricity consumed at the Port of Virginia terminals and buildings.

5.1 Operational Profiles

Electrical power is supplied by Dominion Energy[4]. The Port provided the 2023 electricity consumption in kilowatt hours (kWh) for the various meters and reporting period. For 2023 calendar year, the Port consumed 113,578,712 kWh, of which 88% was from clean energy sources and the remaining 12% from regular or generic grid power sources. The Port provided the percentages calculated from electricity consumed and the purchases of renewable and/or carbon neutral electricity. The kWh is converted to MWh in order to calculate the emissions.

Table 5.1: 2023 Electricity Consumption Summary

Year	Total Electricity Consumption kWh	Carbon Free Clean Energy kWh	Residual Energy kWh
2023	113,578,712	99,949,267	13,629,445

5.2 Emissions Estimation Methodology

Generally, GHG emissions are calculated using the following formula:

$$\boldsymbol{GHG\ Emissions = EF \times Activity}$$

Where:

E = emissions, tonnes or metric tons (MT)
EF = emission factor, lb/MWh
Activity = electricity consumption, kWh or MWh

The emission factor and activity are specific to the source type. The activity for the scope 2 emissions is the electricity consumed. Two sets of emission factors provided by Dominion Energy for location and market-based emissions were used to estimate the emissions.

Market-based carbon intensity includes emissions from all owned generation sources, and it also includes the adjustments to account for sales and retirements of renewable energy certificates (RECs) and purchase of renewable electricity without its associated RECs.

Location-based carbon intensity includes emissions from all owned generation sources but does not account for electricity that was sold to premium paying green tariff customers nor does it account for the sale or retirement of RECs.

[4] See: *www.dominionenergy.com/*

Table 5.2 shows the summarized market-based and location-based carbon intensities that were used in the calculations. The EPA eGrid emission factors[5] for 2023 were not available at the time of this report to compare to the Dominion Energy emission factors.

Table 5.2: Scope 2 Emission Factors

Year	Location-based CO_2e EF lb/MWh	Market-based CO_2e EF lb/MWh
2023	608	579

Table 5.3 lists the location-based carbon intensity as utility average and market-based carbon intensity as residual mix.

Table 5.3: Scope 2 Emission Factors and Generation Mix Provided by Dominion Energy

Dominion Energy Virginia

DEV Customer Carbon Intensity – Residual Mix

Year	lbs / MWh	MT/MWh
2022	653	0.296
2023	579	0.263

DEV Customer Carbon Intensity – Utility Average

Year	lbs / MWh	MT/MWh
2022	668	0.303
2023	608	0.276

DEV Generation Mix

Generation Fuel Type	2022	2023
Coal	8%	5%
Oil	0%	0%
Natural Gas	37%	37%
Other Fossil	0%	0%
Nuclear	28%	30%
Hydro	0%	0%
Biomass	1%	1%
Wind	0%	0%
Solar	1%	1%
Geothermal	0%	0%
Other (Purchased Power)	24%	25%

[5] See: *www.epa.gov/egrid*

5.3 Emission Estimates

Table 5.4 summarizes the resulting emissions using the location and market-based carbon intensities provided by Dominion Energy. For the location-based emissions, the total electricity consumption was used with the location based emission factor provided. For the 2023 market-based emissions, only 12% of the total electricity consumption was used to calculate the emissions as 88% of the total electricity consumed is from carbon free clean energy.

Table 5.4: Scope 2 Emissions, tonnes

Year	Location-based CO_2e tonnes	Market-based CO_2e tonnes
2023	31,332	3,581

SECTION 6 CHE EMISSIONS COMPARISON

In 2019, the Port of Virginia completed a Comprehensive Air Emissions Inventory for 2017 Calendar Year[6] which provided the 2017 emissions along with prior year emissions (2011 and 2014) and forecasted 2020 emissions. The emission sources included in the reports varied according to areas of focus. The vehicle emissions were not part of the 2017 EI, so the only source category compared is CHE. The methodology used to estimate the CHE is comparable using the MOVES model, but there may be some slight variances due to EPA updating the model since the 2017 EI report.

Table 6.1 shows the comparison of 2023 and 2017 CHE emissions. In 2023, all pollutants have significantly lower emissions as compared to 2017. The emissions are lower due to the use of newer and cleaner diesel equipment and transitioning to using electric and hybrid equipment to move cargo. This transition not only lowered the criteria pollutants significantly, but also lowered the GHG emissions. There are less fossil fueled equipment in 2017 moving more cargo due to the use of electric equipment.

Table 6.1: 2017 vs 2023 CHE Emissions Comparison

Year	NO_x tons	PM_{10} tons	$PM_{2.5}$ tons	VOC tons	CO tons	SO_2 tons	CO_2e tons
2017	243.8	19.6	19	30.8	199.3	0.3	32,800
2023	62.9	3.9	3.8	6.1	47.9	0.1	22,103
Change	**-74%**	**-80%**	**-80%**	**-80%**	**-76%**	**-79%**	**-33%**

Figure 6.1 shows the emissions reductions for NOx, PM, SO_2 and GHG emissions over the years since 2011.

[6] Port of Virginia, *Comprehensive Air Emissions Inventory 2017 Update*, prepared by Aegis Environmental, November 2019.

Figure 6.1: CHE Emissions Trends