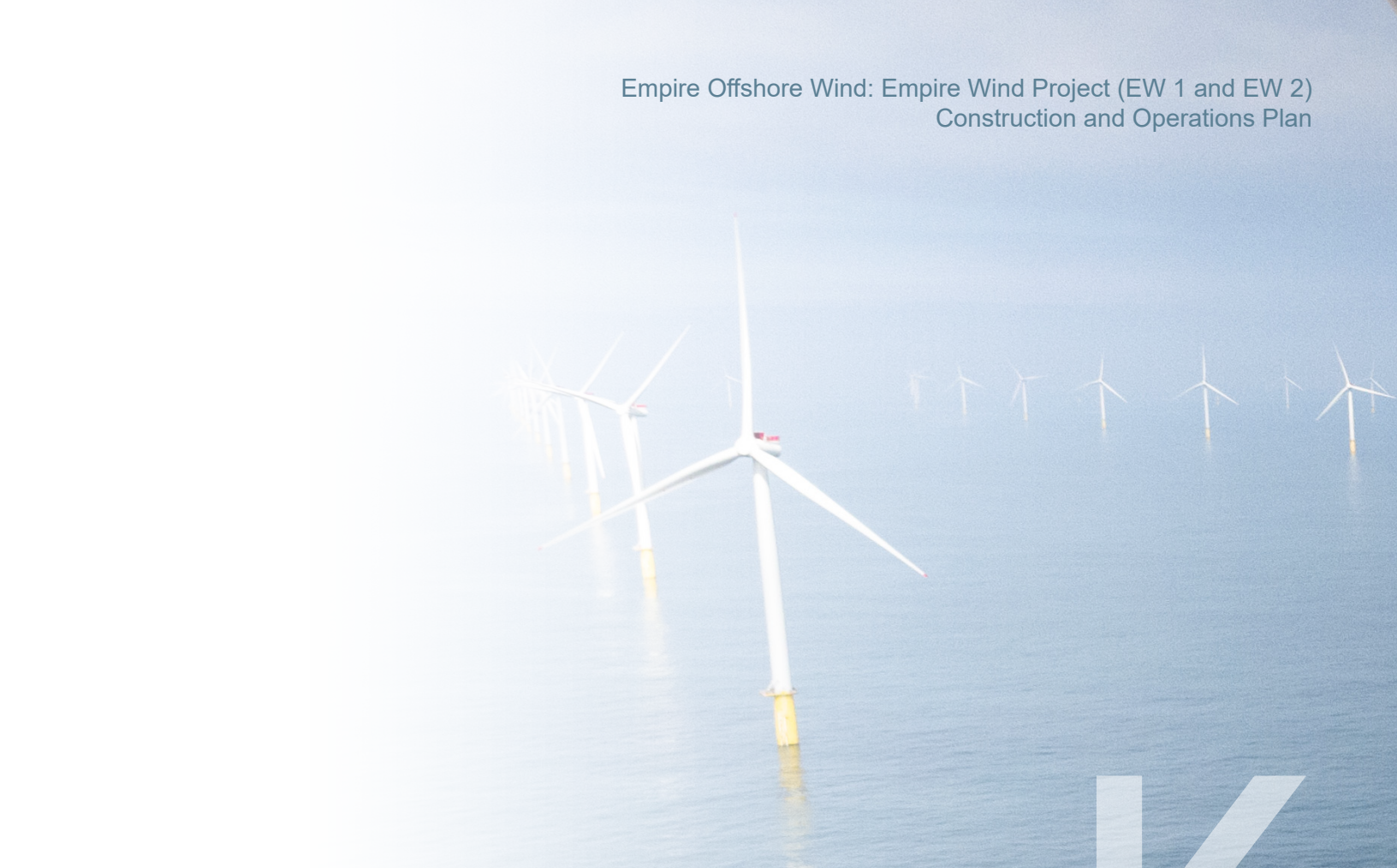
The latest revision date of Appendix K to the Empire Offshore Wind COP is July 2023. This appendix was not revised as part of the November 2023 submittal; therefore, the date on the Appendix K cover sheet remains as July 2023.



APPENDIX K

Air Emissions Calculations and Methodology

Prepared for

equinor

TETRA TECH

JULY 2023

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ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

AQCR	Air Quality Control Region
BOEM	Bureau of Ocean Energy Management
Btu	British thermal units
CFR	Code of Federal Regulations
CH_4	Methane
CMV	commercial marine vessels
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
Empire	Empire Offshore Wind LLC
EPA	U.S. Environmental Protection Agency
EW 1	Empire Wind 1
EW 2	Empire Wind 2
g/hp-hr	grams per horsepower hour
g/kW-hr	grams per kilowatt hour
gal	gallon
GHG	greenhouse gas emissions
GWP	Global Warming Potential
HAP	Hazardous Air Pollutant
hp	Horsepower
kW	kilowatt
L/cyl	liters per cylinder
lb	pound
Lease Area	designated Renewable Energy Lease Area OCS-A 0512
MARPOL	International Convention on the Prevention of Pollution from Ships
MOVES	Motor Vehicle Emission Simulator
N_2O	nitrous oxide
NEPA	National Environmental Policy Act
nm	nautical mile
NO_X	nitrogen oxides
O&M	operations and maintenance
OCS	Outer Continental Shelf
OGV	ocean-going vessels

PM	particulate matter
PM_{10}	particulate matter 10 micrometers in diameter
$PM_{2.5}$	particulate matter 2.5 micrometers in diameter
Project	The offshore wind project for OCS A-0512 proposed by Empire Offshore Wind LLC consisting of Empire Wind 1 (EW 1) and Empire Wind 2 (EW 2).
Project Area	The area associated with the build out of the Lease Area, submarine export cable routes, interarray cables, and all onshore Project facilities.
SBMT	South Brooklyn Marine Terminal
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
VOC	volatile organic compound

K.1 INTRODUCTION

Empire Offshore Wind LLC (Empire) proposes to construct and operate an offshore wind facility, to be located in the designated Renewable Energy Lease Area OCS-A 0512 (Lease Area). The Lease Area covers approximately 79,350 acres (32,112 hectares) and is located approximately 12 nautical miles (nm, 22 kilometers [km]) south of Long Island, New York and 16.9 nm (31.4 km) east of Long Branch, New Jersey (**Figure K-1**).

Empire proposes to develop the Lease Area in two wind farms, known as Empire Wind (EW) 1 and Empire Wind 2 (EW 2), collectively referred to hereafter as the Project. EW 1 and EW 2 are both covered in this Construction and Operations Plan (COP). EW 1 and EW 2 will be electrically isolated and independent from each other. Each wind farm will connect via offshore substations to separate Points of Interconnection (POIs) at onshore locations by way of export cable routes and onshore substations. In this respect, the Project includes two onshore locations in New York where the renewable electricity generated will be transmitted to the electric grid.

This report describes the methodology applied to calculate the anticipated air emissions associated with construction, operation, and decommissioning of the Project, as well as the results of the emissions calculations, which are detailed in **Attachment K-1, Emission Calculations**. Vessel specifications and durations have been selected to represent a maximum design scenario with respect to the potential emissions associated with construction, operation, and decommissioning of the Project. The actual vessels to be employed during construction, operation, and decommissioning are subject to change. There are seven categories of sources for which emissions were calculated:

- Commercial marine vessels (CMVs);
- Helicopters;
- Stationary diesel generator engines;
- Portable diesel generator engines;
- Gas-insulated switchgear;
- Nonroad engines; and
- On-road vehicles.

The specific air pollutants estimated from the listed source categories consist of criteria air pollutants, hazardous air pollutants (HAPs), and greenhouse gases (GHGs). Specific pollutants in each group are as follows:

- Criteria Air Pollutants:
  - Ground-level ozone;
  - Nitrogen dioxide (NO_2);
  - Carbon monoxide (CO);
  - Total particulate matter (PM);
  - Particulate matter with aerodynamic diameter 10 micrometers or less (PM_{10});
  - Particulate matter with aerodynamic diameter 2.5 micrometers or less ($PM_{2.5}$);
  - Sulfur dioxide (SO_2); and
  - Lead (Pb).

- Other regulated precursor pollutants include:
  - Volatile organic compounds (VOCs);
  - Oxides of nitrogen (NO_X); and
  - Sulfur dioxide (SO_2).

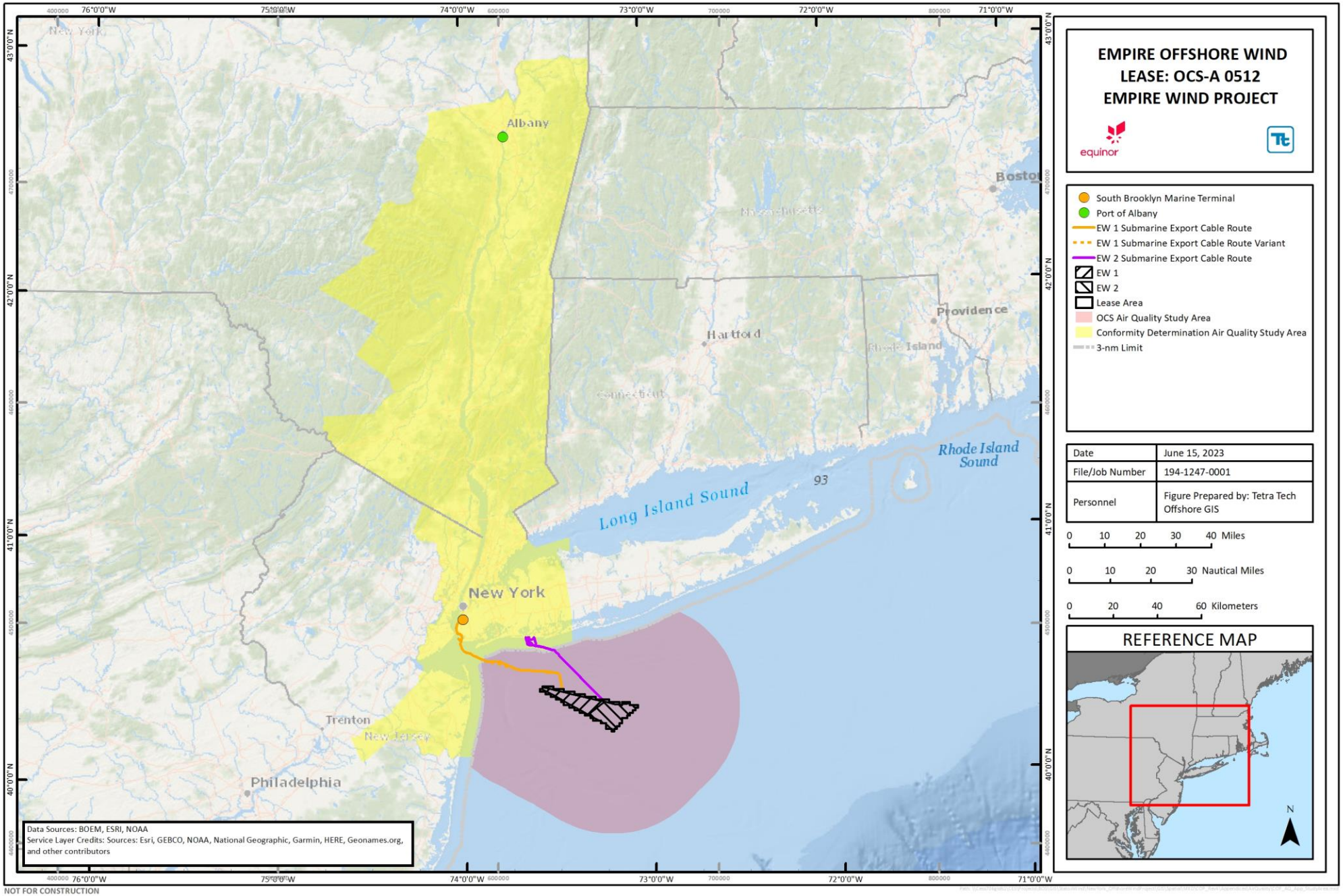

Figure K-1 Project Overview

VOCs and NO_X are the precursors and measured pollutants for the criteria pollutant ozone, and NO_X and SO_2 are precursors for the criteria pollutant $PM_{2.5}$ (SO_2 is also directly emitted, and is itself a criteria pollutant, as identified above.)

- HAPs, which include but are not limited to:
  - Formaldehyde;
  - Acetaldehyde;
  - Benzene;
  - Naphthalene;
  - Acrolein;
  - 1,3-Butadiene;
  - Ethylbenzene; and
  - Polycyclic Organic Matter.

- GHGs also include a range of chemical compounds but the Project will likely emit the following:

  - Carbon dioxide (CO_2);
  - Methane (CH_4);
  - Nitrous oxide (N_2O); and
  - Sulfur hexafluoride (SF_6).

For the purposes of this analysis, emissions of $PM_{2.5}$, PM_{10}, and PM are conservatively assumed to be the same.

K.2 EMISSION CALCULATION METHODS

Methods for calculating criteria pollutant emissions for the respective emission source categories are summarized in Sections K.2.1 through K.2.5. Additionally, Section K.2.6 discusses the methodology for estimating the total GHG emissions for each of the source categories. GHG emissions are presented as "CO_2 equivalent" or (CO_2e), because the different GHG constituents have different heat absorption capacities.

Emission calculations provided in this assessment reflect construction, operations, and decommissioning of up to 147 wind turbines, consistent with other required permitting.

K.2.1 Commercial Marine Vessels

The calculations presented in **Attachment K-1** are based on assumed typical vessels representative of the types, configurations, and sizes that the Project anticipates will be employed during the construction, operations, and decommissioning phases of the Project. Vessel specifications have been selected to represent a maximum design scenario with respect to the potential emissions of the identified vessel category. Actual vessels to be employed during construction, operations, and decommissioning activities are subject to change. Vessel operating durations are based on anticipated schedules provided by the Project and may also be subject to change. However, the durations presented within have been selected to represent a maximum design scenario with respect to potential emissions (i.e., conservative estimates).

K.2.1.1 Default Emission Factors

At this phase in the planning process some vessels have been contracted and are reflected in the emissions calculations. However, for vessels that have not yet been contracted, the actual vessels to be used are subject to change, and it is not possible to know with certainty what emission standards a particular vessel is certified to meet. Therefore, emissions from most vessels have been estimated using conservative default emission factors from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for

Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022 (EPA 2022). The values from the 2022 EPA guidance document that were selected as default emission factors for the Project's marine vessel engines are presented below in **Table K-1**.

Vessel engines were classified as either **Category 1, Category 2** or **Category 3** based on the following size ranges:

- **Category 1:** Engines with a displacement of less than 5 liters per cylinder (or less than 7 liters per cylinder, if subject to 40 Code of Federal Regulations [CFR] Part 1042).
- **Category 2:** Engines with a displacement greater than or equal than 5 liters per cylinder, but less than 30 liters per cylinder (or between 7 and 30 liters per cylinder, if subject to 40 CFR Part 1042). **Category 3:** Engines with a displacement equal to or greater than 30 liters per cylinder.

Table K-1 Summary of Default Emission Factors for Marine Engines

Marine Engine Category	Emission Factor (g/kW-hr) a/ b/								
	NO_X	VOC	CO	PM/PM_{10} c/	$PM_{2.5}$ d/	SO_2 e/	CO_2	CH_4	N_2O
Category 1, Tier 1/2, kW ≥ 37, all displacement ranges (propulsion)	9.8	0.4317	1.8	0.43	0.417	0.00625	679.47	0.0082	0.0332
Category 1, Tier 1/2, kW ≥ 37, all displacement ranges (auxiliary)	9.8	0.4317	1.8	0.73	0.708	0.00625	679.47	0.0082	0.0332
Category 2, Tier 1/2, all kW ranges, all displacement ranges (propulsion and auxiliary)	10.55	0.1411	2.48	0.309	0.300	0.00625	679.47	0.0027	0.0332
Category 3, 1999 and earlier, MSD engines, MGO/MDO fuel (propulsion)	13.2	0.5265	1.1	0.1867	0.1718	0.4008	657.23	0.01	0.029
Category 3, 1999 and earlier, MSD engines, MGO/MDO fuel (auxiliary)	13.8	0.4212	1.1	0.1886	0.1735	0.4243	695.70	0.08	0.029

Notes:

a/ Default emission factors for NO_X, VOC, CO, PM_{10}, $PM_{2.5}$, SO_2, CO_2, and CH_4 from Category 1 and Category 2 engines are based on the worst case of either the Tier 1 or Tier 2 values in the following sections of the 2022 EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022: Table H.1 for NO_X; Table H.2 for PM_{10} and $PM_{2.5}$; Table H.3 for VOC and CH_4; Table H.4 for CO; Table H.7 for SO_2 and CO_2; and Equation 4.3 for N_2O.

b/ Emission factors for Category 3 engines are based on the values for 1999 and earlier engines in the following sections of the 2022 EPA guidance: Table 3.5 for NO_X; Equation 3.3 for PM_{10}; Table 3.8 for VOC, CO, and CH_4; Equation 3.4 for CO_2; Equation 3.5 for SO_2; and Table 3.9 for N_2O.

c/ All PM is assumed to less than 10 µm in diameter; therefore, PM emission factor is equivalent to PM_{10} emission factor.

d/ For Category 1 and 2 engines, $PM_{2.5}$ is estimated to be 97% of PM_{10}, per section 4.5.3 of the 2022 EPA guidance. For Category 3 engines, $PM_{2.5}$ is assumed to be 92% of PM_{10}, per section 3.5.3 of the 2022 EPA guidance.

e/ SO_2 emission factors assume a fuel sulfur content of: 0.0015 percent by weight for Category 1 and 2 engines (Table H.7 of 2022 EPA guidance); and 0.1 percent by weight for Category 3 engines (Equation 3.5 of 2022 EPA guidance).

The majority of the marine vessels used for the Project are assumed to be equipped with either Category 1 or Category 2 engines and will qualify as "harbor craft" as defined under the California Rule 17 CCR 93118.5. (See Section 4.4.4 for further discussion of the California rule with regard to emission standards for harbor craft.) These categories of engines will use only ultra-low sulfur diesel fuel, which has a sulfur content of 15 parts per million by weight. Many of the larger installation vessels will be equipped with Category 3 main engines, and these vessels have conservatively been assumed to use marine diesel oil with a sulfur content of 0.1 percent by weight, since they could potentially purchase fuel at overseas ports prior to being employed by the Project.

The EPA established a tier structure for emission standards based on the age of the engine and cylinder displacement. Tier 0 (baseline), Tier 1, or Tier 2 apply to engines built prior to 2009. Stricter Tier 3 emission standards apply to engines built starting in 2009. The 2022 EPA guidance document presents emission factors for Tier 1 through Tier 4 (Category 1 and Category 2 engines), and Tier 1 through Tier 3 (Category 3 engines). For the purpose of selecting default emission factors, which might involve the use of vessels with older engines, the highest values provided for each engine category were used to provide a conservative estimate.

For Category 1 and Category 2 engines, default emission factors are based on the worst-case of either the Tier 1 or Tier 2 emission factors provided in the following sections of the 2022 EPA guidance document:

- Table H.1 for NO_X;
- Table H.2 for PM_{10} and $PM_{2.5}$;
- Table H.3 for VOC and CH_4;
- Table H.4 for CO;
- Table H.7 for SO_2 and CO_2; and
- Equation 4.3 for N_2O.

Only several of the largest construction vessels were assumed to be equipped with Category 3 engines, including the main generator engines and/or main propulsion engines on the following vessel types:

- Heavy lift vessels;
- Heavy transport vessels;
- Anchor handling tugs;
- Fall pipe vessels;
- Monopile installation vessel;
- Wind turbine installation vessels;
- Export cable lay vessels; and
- Dredger vessels.

Default emission factors for Category 3 engines are based on the values for 1999 and earlier engines in the following sections of the 2022 EPA guidance:

- Table 3.5 for NO_X;
- Equation 3.3 for PM_{10};
- Table 3.8 for VOC, CO, and CH_4;
- Equation 3.4 for CO_2;
- Equation 3.5 for SO_2; and
- Table 3.9 for N_2O.

For all engine categories, SO_2 emission factors are based on Table H.7 of 2022 EPA guidance for Category 1 and Category 2 engines (assuming a fuel sulfur content of 0.0015 percent by weight), and Equation 3.5 of 2022 EPA guidance for Category 3 engines (assuming a fuel sulfur content of 0.1 percent by weight).

For all engine categories, all PM is assumed to less than 10 microns in diameter; therefore, PM emissions are equivalent to PM_{10} emissions. For Category 1 and 2 engines, $PM_{2.5}$ is assumed to be 97 percent of the PM_{10} value, based on section 4.5.3 of the 2022 EPA guidance. For Category 3 engines, $PM_{2.5}$ is assumed to be 92 percent of the PM_{10} value, based on section 3.5.3 of the 2022 EPA guidance.

Emission factors for HAPs from commercial marine vessels were determined using the methodology identified by EPA for the 2017 National Emissions Inventory. The emission factors for individual HAP compounds are provided as percentages of the $PM_{2.5}$ or VOC emissions from the CMVs. These are tabulated in **Attachment K-1**.

Fuel consumption for Category 1 and Category 2 engines is based on the brake specific fuel consumption value provided in section 4.5.2 of the 2022 EPA guidance for engines ≥ 37 kW, with an assumed fuel density of 3.18 kg/gallon. Fuel consumption for Category 3 engines is based on the brake specific fuel consumption values for Category 3 main and auxiliary engines (fuel type MGO/MDO) provided in Table 3.6 of the 2022 EPA guidance, with an assumed fuel density of 3.18 kg/gallon.

As a comparison to EPA's tiered emission standards, the International Maritime Organization has also established three tiers of emission standards for marine engines, under Regulation 13 in Annex VI of the International Convention on the Prevention of Pollution from Ships (MARPOL). However, the MARPOL standards only establish emission limits for NO_X, and they do not categorize engines by rated power or displacement, but only by date of construction and rated engine speed in revolutions per minute. Thus, all marine engines constructed from 2000 through 2010 are subject to the MARPOL Tier I NO_X standard, all engines constructed from 2011 through 2015 are subject to the MARPOL Tier II NO_X standard, and all engines constructed from 2016 onward are subject to the MARPOL Tier III NO_X standard. EPA's Tier 1, 2, and 3 NOx emission standards for Category 3 engines (displacement ≥ 30 liters per cylinder) are identical to MARPOL's Tier I, II, and III standards, but EPA also includes emission standards for CO and hydrocarbons. EPA's tiered NO_X standards for Category 1 and Category 2 engines do not correspond to the MARPOL standards, and also include emission standards for hydrocarbons and PM.

K.2.1.2 EPA Tier 2, Tier 3, and Tier 4 Emission Factors

Empire is currently in the process of securing contracts with vessel operators for construction, operation, and maintenance of the Project. In cases where it is expected that suitable vessels will be assured of meeting at least EPA Tier 2 emission standards for marine engines, as set forth in 40 CFR Part 1042, these Tier 2 standards have been used to estimate emissions. Where possible, Empire is seeking to further reduce the Project's potential emissions by securing commitments to use vessels that are certified to meet EPA's Tier 3 or Tier 4 emission standards for marine engines. At the time of this permit application submittal, Empire has assumed the use of EPA Tier 3 marine vessels for the following tasks:

- Heavy Transport Vessels used during installation of monopiles and transition pieces for EW 1 and EW 2;
- Heavy Transport Vessels used for transport of the offshore substation foundations and topsides for EW 1 and EW 2;
- Main Installation Vessel used for wind turbine installation and wind turbine maintenance for EW 1 and EW 2;

- Tender Support Vessel used during export cable installation for EW 1; and
- Export Cable Lay Vessel used during export cable installation for EW 2.

For the above vessels, potential emissions for NO_X, CO, VOC, and PM have been estimated using the appropriate EPA Tier 3 emission standards published in 40 CFR § 1042.101 (Category 1 and 2 engines) or 40 CFR § 1042.104 (Category 3 engines), as applicable. Emissions of SO_2 and HAPs from EPA Tier 3 and Tier 4 engines have been estimated using the same default emission factors described above.

Empire is aware that similar offshore wind projects have proposed to use a "primary crew transfer vessel" that meets the EPA Tier 4 standards at 40 CFR Part 1042 (for Category 1 and 2 engines at 600 kW or greater) and the EPA Tier 3 standards at 40 CFR Part 1042 (for Category 1 and 2 engines below 600 kW). Empire Wind will adopt the definition of "primary crew transfer vessel" that similar offshore wind projects have proposed to use. At the time of this permit application submittal, Empire has assumed the use of EPA Tier 4 marine vessels for the following tasks:

- One Primary Crew Transfer Vessel used during installation of monopiles and transition pieces for EW 1 and EW 2;
- One Primary Crew Transfer Vessel used during commissioning for EW 1 and EW 2;
- Four Primary Crew Transfer Vessels used during operations and maintenance for EW 1 and EW 2; and
- One Service Operations Vessel used during operations and maintenance of EW 1 and EW 2.

K.2.1.3 Load Factors

For all marine vessel activities, including construction activities and transits to and from shore, average engine load factors for each vessel type were estimated based on assumed average daily fuel use rates provided by the Project.

K.2.1.4 Calculation of Emissions

The basic equation used to estimate annual emissions from each CMV engine and activity is:

$$E = kW \times Act \times LF \times EF$$

Where:

E = emission, grams/year
kW = kilowatts (engine rating)
Act = activity, hours/year
LF = engine load factor (for the activity)
EF = emission factor, g/kW-hr

The calculated emissions were converted to tons per year by dividing the emissions by the conversion factor from grams to pounds (453.6 g/lb) and by the conversion factor from pounds to tons (2,000 lb/ton).

The CO_2e (GHG) emissions for the CMVs were calculated based on the methodology presented in Section K.2.6.

K.2.2 Stationary Engines

K.2.2.1 Offshore Substation and Onshore Substation Generator Engines

The offshore substation platform for both EW 1 and EW 2 is assumed to be equipped with one diesel generator engine rated at 600 kW mechanical output. The offshore substation generator engines are assumed to be used both for emergency and non-emergency generation, including readiness testing and maintenance purposes. Potential emissions were estimated by conservatively assuming up to 2,000 operating hours per year for each engine.

Each onshore substation is also assumed to be equipped with one diesel generator engine rated at 600 kW mechanical output. The onshore substation generator engines are assumed to be used only for emergency generation, as well as for readiness testing and maintenance purposes. For the onshore substation engines, potential emissions were estimated by conservatively assuming up to 500 operating hours per year for each engine.

For the offshore substation engines, emissions of NO_X, CO, VOC, and PM were assumed to meet the corresponding EPA Tier 4 final emission standards in Table 1 of 40 CFR § 1039.101 for generator engines of the appropriate size category. For the onshore substation engines, emissions of NO_X, CO, VOC, and PM were assumed to meet the corresponding EPA Tier 2 emission standards in Table 1 of 40 CFR § 89.112 for emergency generator engines of the appropriate size category.

Emissions of SO_2 were based on a mass balance assuming a fuel sulfur content of 0.0015 percent by weight, and 100 percent conversion of fuel sulfur to SO_2. Emissions of HAPs for the engines were based on factors presented in EPA's AP-42 Compilation of Air Pollutant Emission Factors (AP-42) Section 3.4 for large diesel engines (EPA 1996). Emissions for GHG pollutants (CO_2, CH_4, and N_2O) were based on the emission factors presented in 40 CFR Part 98 Tables C-1 and C-2.

Emission rates provided in grams per kilowatt-hour were multiplied by the engine's assumed power rating (kW) and by the total annual operating hours (assumed to be 500 hours per year for each engine). The calculated emissions were converted to tons per year by dividing the emissions by the conversion factor from grams to pounds (453.6 g/lb) and by the conversion factor from pounds to ton (2,000 lb/ton).

Emissions calculated using AP-42 emission factors (lb/ MMBtu) were multiplied by the heat input rate (MMBtu/hr) (calculated from generator's fuel consumption [gallons] and the diesel fuel's heat content [Btu/gal]), and by the total annual operating hours, converting from pounds to ton (2,000 lb/ton).

K.2.3 Marine Auxiliary Engines on Vessels

A total of three marine auxiliary engines are anticipated to be used for certain short-duration tasks during construction and commissioning of the Project. The numbers of engines and their rated power outputs are estimated, based on the current Project design.

- One 1,632-kW generator engine located on the heavy lift vessel for monopile installation, to provide power to a gripper frame that compensates for wave action to hold each monopile in a fixed position during installation;
- One 750-kW engine operating for approximately 400 days at the EW 1 offshore substation, and for approximately 700 days at the EW 2 offshore substation, to provide power during commissioning of each offshore substation topside structure (this engine has been assumed to be a marine vessel engine for the purpose of estimating emissions); and

- One 1,200-kW engine operating for approximately 9 hours at each wind turbine, to provide power during installation of each wind turbine (this engine has been assumed to be a marine vessel engine for the purpose of estimating emissions).

The 1,632-kW gripper frame engine will be located on the deck of the heavy lift vessel for monopile installation. The 1,200-kW wind turbine installation engine and the 750-kW offshore substation commissioning engine will be located on the wind turbine main installation vessel, and on the jack-up vessel for offshore substation hookup and commissioning, respectively, with power supplied through a cable while the vessel is tied up to the structure. It is also possible that a marine vessel's own generator engine could be used to provide power for the wind turbine installation and offshore substation commissioning tasks.

Since the 1,200-kW wind turbine installation engine and the 750-kW offshore substation commissioning engine could potentially be a marine vessel's own generator engine, emissions for all pollutants from these engines were conservatively estimated using the emission factors described in Section 2.5.1 for Category 2 marine engines.

K.2.4 Portable Diesel Generator Engines

Approximately 23 portable diesel generator engines will be required during construction and commissioning of the Project, as well as during potential unplanned emergency events during operations and maintenance (O&M) of the Project, including the following tasks:

- One 350-kW engine operating for approximately 60 days at each offshore substation, to provide power for welding machines, lighting, and other tasks during installation of each offshore substation topside structure;
- Three 150-kW engines, operating at three separate wind turbines simultaneously, for approximately 72 hours at each location, to provide power during commissioning of each wind turbine;
- One 15-kW engine operating for approximately 50 hours at each wind turbine, to provide power to pull the interarray cables into each wind turbine tower;
- One 15-kW engine operating for approximately four days at each offshore substation, to provide power to pull the interarray cables into each offshore substation topside structure;
- One 25-kW engine operating for approximately four days at each offshore substation, to provide power to pull the submarine export cable into each offshore substation topside structure ; and
- Up to sixteen 150-kW engines, operating for approximately six days each, estimated to occur separately at EW 1 or EW 2, up to once every 10 years per EW 1 and per EW 2, to provide emergency power at individual wind turbines during operations and maintenance.

Each of the portable diesel generators will be lifted onto each offshore substation or wind turbine prior to use, and will be retrieved from each substation or wind turbine after use.

For the portable diesel generators that will be lifted onto an offshore substation or wind turbine, emissions of NO_X, CO, VOC, and PM were assumed to meet the corresponding post-2014 nonroad emission standards in Table 1 of 40 CFR § 1039.101 for generator sets of the appropriate size category. Emissions of SO_2 were based on a mass balance assuming a fuel sulfur content of 0.0015 percent by weight, and 100 percent conversion of fuel sulfur to SO_2. Emissions of HAPs for the engines were based on factors presented in AP-42 Section 3.3 for small diesel engines (EPA 1996). Emissions for GHG pollutants (CO_2, CH_4, and N_2O) were based on the emission factors presented in 40 CFR Part 98 Tables C-1 and C-2.

K.2.5 Non-road Engines

Emissions factors for mobile source, non-road engines to be used during the construction of the onshore substation, onshore export cable, and interconnection cables for EW 1 and EW 2 (including cranes, forklifts, excavators, front end loaders, generators, HDD drill rigs, and other construction equipment) were calculated using the EPA's Motor Vehicle Emission Simulator (MOVES2014b) emission factor modeling system (EPA 2014). To calculate emission factors for the Project, a run was conducted for a conservatively assumed construction start year of 2023, using the national database and inventory mode.

Emission factors from the EPA's MOVES2014b emission model are provided in units of g/hp-hr, so emissions were estimated by multiplying the emission factor by the non-road engine's assumed power rating (hp), the total operating hours, and the load factor for each different type of machine. Typical load factors for various equipment types were based on Appendix A of EPA's "Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling" (EPA 2010). The calculated emissions were converted to tons per year by dividing the resultant emissions in grams per year by the conversion factor from grams to pounds (453.6 g/lb) and by the conversion factor from pounds to ton (2,000 lb/ton). Emissions of HAPs are based on factors from ERG (2003, as cited in EPA 2005) Appendix D, Tables D-1 through D-3. Emissions for CH_4 and N_2O are based on EPA emission factors for construction equipment in Table B-8 of the EPA report on "Direct Emissions from Mobile Combustion Sources" (0.57 g CH_4/gal fuel and 0.26 g N_2O/gal fuel, respectively) (EPA 2016). Fuel consumption for each type of equipment was estimated based on CO_2 emission factor (g/hp-hr) generated from the MOVES2014b model and the emission factor for the mass of CO_2 generated per gallon of diesel fuel (10.21 kg CO_2/gal fuel), as presented in Table A-1 of the EPA (2016) report.

Therefore, CH_4 and N_2O emissions were calculated based on the following equation:

$$E = FC \times \varrho \times EF \times 0.4536 \text{ (kg/lb)} \times \text{Eng. Rating} \times \text{Act} \times LF \,/\, 453.6 \text{ (g/lb)} \,/\, 2{,}000 \text{ (lb/ton)}$$

Where:

E = Emissions, tons/year
FC = Fuel consumption, gal/hp-hr
ϱ = Density, lb/gal
EF = Emission Factor, g (CH_4 or N_2O)/kg fuel
Eng. Rating = Engine Rating, hp
Act = Activity, hours/year
LF = Load Factor

The CO_2e (GHG) emissions were calculated based on the methodology presented in Section K.2.5.

K.2.6 On-road Vehicles

MOVES2014b was used to estimate emissions associated with on-road engines used during construction of the onshore substation, onshore export cable, and interconnection cable for EW 1 and EW 2, for a conservatively assumed construction start year of 2023. This emission modeling system estimates emissions for a broad range of pollutants from mobile sources such as cars, trucks, and motorcycles, and allows multiple scale analysis.

Emission factors (in pounds per vehicle mile traveled) for VOC, NO_X, CO, PM, SO_2, and CO_2e were calculated for 2020 using the most current database files input into MOVES2014b. Input values were provided by the New York State Department of Environmental Conservation for each county in which the onshore construction would occur, including:

- Kings County (EW 1 onshore substation, O&M Base, and interconnection cables); and
- Nassau County (EW 2 onshore substation, onshore export cables, and interconnection cables).

K.2.7 Helicopter Emissions

One helicopter is currently assumed to be used to perform crew transfers during the foundation installation, wind turbine generator, and submarine export cable installation tasks for both EW 1 and EW 2. The Bureau of Ocean Energy Management (BOEM) has produced a technical document, "BOEM Offshore Wind Energy Facilities Emission Estimating Tool - Technical Documentation" (BOEM 2017), to assist in estimating emissions for construction and operations of offshore wind energy facilities, including emissions from helicopters. Table 4 of the 2017 BOEM document provides default emission factors for VOC, NO_x, CO, PM, SO_2, CO_2, CH_4, and N_2O, as well as default fuel consumption rates in gallons/hour, based on four categories of helicopter size. Table 9 of the 2017 BOEM document provides default airspeeds for each category of helicopter size. Emissions of HAPs for the helicopter engines were based on factors presented in EPA's 1996 AP-42 Compilation of Air Pollutant Emission Factors (AP-42) Section 3.4 for large diesel engines.

Emissions for helicopter crew transfers during construction were estimated assuming a large twin-engine helicopter capable of carrying 20-30 passengers. The "Twin Heavy" helicopter category was selected from the 2017 BOEM document, with a default airspeed of 188.2 miles/hour. Although the airport for helicopter flights has not been selected, travel distances and durations were estimated using JFK International Airport as the assumed departure location. Emissions were based on two round trips per week for the duration of foundation installation, wind turbine generator installation, and submarine export cable installation tasks for EW 1 and EW 2, with a round trip duration of 30 minutes per flight.

K.2.8 Gas-Insulated Switchgear

The offshore substation platforms, wind turbine towers, and onshore substations will all be equipped with high-voltage circuit breakers ("switchgear") that use SF_6 as an insulating material. SF_6 is a GHG that slowly leaks from the sealed switchgear housings into the air. The offshore substation platforms and onshore substations are still being designed, and information about the proposed switchgear will be included in the Facilities Design Report and Fabrication and Installation Report. Emissions of SF_6 from the wind turbine switchgear were estimated using the switchgear counts and storage quantities provided by the Project, and assuming an annual leakage rate of 0.5 percent by weight per year (IEC 2004, as cited in EPA 2017).

K.2.9 Global Warming Potentials

The GHG emissions from the Project are a result of the combustion of diesel fuel that produces emissions of CO_2, CH_4, and N_2O, as well as leakage of SF_6 from gas-insulated switchgear. GHGs are typically presented as CO_2 equivalent or "CO_2e", based on the specific Global Warming Potential (GWP) for each gas.

Each GHG constituent has a different heat trapping capability. The corresponding GWP has been calculated by the EPA to reflect how long the gas remains in the atmosphere, on average, and how strongly it absorbs energy compared to CO_2. Gases with a higher GWP absorb more energy, per pound, than gases with a lower GWP.

Factors used to calculate CO_2e (GWP) were taken from Table A-1 of 40 CFR Part 98, Subpart A. The GWPs are 25 for CH_4, 298 for N_2O, and 22,800 for SF_6.

Therefore, the equation to calculate CO_2e for each source is:

$$CO2e = \left[CO2\,\frac{tons}{yr}\ x\ CO2\ GWP(1)\right] + \left[CH4\,\frac{tons}{yr}\ x\ CH4\ GWP(25)\right] + \left[N2O\,\frac{tons}{yr}\ x\ N2O\ GWP(298)\right] + \left[SF6\,\frac{tons}{yr}\ x\ SF6\ GWP(22{,}800)\right]$$

K.3 GEOGRAPHIC ALLOCATION OF EMISSIONS

Some of the CMVs will make a number of round trips to and from shore. Trips to and from shore will be made for multiple purposes, including loading of construction materials and equipment, refueling and restocking of supplies, crew transfers, and other purposes. Vessel transits will be made between the Project Area and an onshore port location(s). Therefore, portions of the vessel emissions from each transit will occur in distinct geographic areas for the purposes of regulatory applicability.

For example, transit emissions within 25 nm (46 km) of the Lease Area will be assigned to the OCS source potential emissions inventory. Transit emissions occurring in state waters will be assigned to the General Conformity potential emissions inventory for the specific nonattainment or maintenance area in which they occur, or to the attainment area potential emissions inventory for the purpose of addressing National Environmental Policy Act (NEPA) requirements. Likewise, emissions associated with construction and installation of the offshore Project elements but occurring outside the 25-nm (46-km) radius around the Lease Area are considered for NEPA purposes only and are not part of the OCS source potential emissions inventory. Those portions of the transit emissions that occur in waters located beyond 3 nm from shore and also beyond 25 nm (46 km) from the Lease Area (chiefly consisting of transits from overseas ports) have not been included in either potential emissions inventory.

Empire has assumed that the South Brooklyn Marine Terminal (SBMT) will be the local port and staging area for all purposes, with the following exceptions:

- Monopile foundations could be sourced from overseas and either staged in Canada or brought directly to their offshore installation locations;
- Although the wind turbine towers are likely to be transported from Europe, the Port of Albany on the Hudson River in upstate New York may still potentially be an option, and is conservatively assumed to be the starting point for the transit of the wind turbine towers;
- A submarine cable factory just north of Charleston, South Carolina is assumed to be the starting point for the transit of submarine cables;
- A yet-to-be-determined port in the Corpus Christi, Texas area is assumed to be the starting point for transporting the offshore substation topsides for EW 1 and EW 2, to the installation locations in the Lease Area. These will be brought directly to their offshore construction locations by a heavy transport vessel; and
- Halifax, Nova Scotia is assumed to be the starting point for the transit of scour protection rock and gravel. Rock and gravel will be brought directly to the offshore construction locations by a fall pipe vessel.

Empire notes that the supply chain for the offshore wind industry is in its nascent stages but is quickly developing. Therefore, as construction planning continues, U.S. ports could instead be selected for the staging of major offshore wind components. The inventory and any associated OCS air permits for the Project will be updated as additional details become available, subject to Empire's contracting commitments.

Finally, any air emissions associated with the manufacture or fabrication of project components at U.S. ports will be addressed in the relevant air permits issued to the port owners for operation of the required manufacturing facilities.

K.3.1 Vessel Transits to Shore

To determine the maximum potential transit emissions for General Conformity and NEPA review purposes, the following one-way transit distances from the Lease Area to SBMT, from a Texas port to the Lease Area, and from a South Carolina port to the Lease Area, were used to allocate vessel transit emissions by geographic area. Assuming an average transit speed of 5 knots (9 km/hr) for tugs and barges, and 10 knots (18.5 km/hr)for all other vessels:

- SBMT to center of the Lease Area (each way):
  - Kings County, NY: 7.8 nm (14.5 km)
  - Queens County, NY: 3.0 nm (5.5 km)
  - Monmouth County, NJ: 2.7 nm (5 km)
  - Inside OCS radius: 30 nm (55.6 km)
    - **TOTAL DISTANCE = 43.5 nm (80.5 km)**

- Texas port to center of the Lease Area (one-way transit):
  - State waters within Corpus Christi-Victoria AQCR, Texas: 30.0 nm (55.6 km)
  - Federal waters outside OCS radius: 1,940 nm (3,592.9 km)
  - Inside OCS radius: 30 nm (55.6 km)
    - **TOTAL DISTANCE = 2,000 nm (3,704 km)**

- South Carolina submarine cable supplier to center of the Lease Area (one-way transit):
  - State waters within Charleston Intrastate AQCR, South Carolina: 23 nm (42.6 km)
  - Federal waters outside OCS radius: 590 nm (1,092.7 km)
  - Inside OCS radius: 30 nm (55.6 km)
    - **TOTAL DISTANCE = 643 nm (1,190.8 km)**

Emissions for all transits located within the 25-nm (46-km) OCS source perimeter are inventoried for the OCS air permit screening applicability.

Emissions for all transits located within state waters are inventoried either for the General Conformity assessments (if within a designated nonattainment or maintenance area) or for NEPA purposes (if located outside a designated nonattainment or maintenance area). Note that emissions resulting from operations of the port facilities themselves are not included in either the General Conformity or NEPA inventories. The port facilities are responsible for such emissions, which are subject to state stationary source air permitting requirements, and are therefore explicitly exempt from General Conformity requirements.

Emissions for those portions of transits that are outside the 25-nm (46-km) OCS source perimeter (and are also outside state waters) have not been inventoried, with the exception of the offshore substation topside transits from Texas and the submarine cable supply transits from South Carolina. Generally, this results in exclusion of most of the ocean-crossing transit distance from overseas ports to SBMT, or from overseas ports directly to the offshore construction area.

K.3.2 Foundation Transport

For the monopile wind turbine foundation and piled jacket offshore substation foundation, it has been assumed that all foundation structures and pilings would be manufactured at another location (outside the U.S.) and may be staged for assembly at SBMT. Foundation structures and pilings could also potentially be directly supplied to the field for installation.

K.3.3 Wind Turbine Tower Transport

Empire may use the Port of Albany to transport the wind turbine generator towers down the Hudson River. Tugs and barges would first move the wind turbine towers to SBMT, and then continue moving them to the offshore installation location.

For the purpose of estimating transit emissions, the total distance for each transit has been assumed to be the sum of the distance from Port of Albany to SBMT, plus the distance from SBMT to the center of the Lease Area:

- Southbound counties along the Hudson River (Port of Albany to SBMT):
  - Albany County, NY: 10.3 nm (19.1 km)
  - Greene County, NY: 22.7 nm (42.0 km)
  - Ulster County, NY: 33.5 nm (62.0 km)
  - Orange County, NY: 18.0 nm (33.3 km)
  - Rockland County, NY: 21.6 nm (40.0 km)
  - Bergen County, NJ: 12.7 nm (23.5 km)
  - Hudson County, NJ: 7.5 nm (13.9 km)
  - Kings County, NY: 2.0 nm (3.7 km)
    - **TOTAL DISTANCE = 128.3 nm (237.6 km)**
- Northbound counties along the Hudson River (SBMT to Port of Albany):
  - Albany County, NY: 0.1 nm (0.2 km)
  - Rensselaer County, NY: 10.2 nm (18.9 km)
  - Columbia County, NY: 26.0 nm (48.1 km)
  - Dutchess County, NY: 39.9 nm (73.9 km)
  - Putnam County, NY: 8.2 nm (15.2 km)
  - Westchester County, NY: 27.0 nm (50.0 km)
  - Bronx County, NY: 2.2 nm (4.0 km)
  - New York County, NY: 12.9 nm (23.9 km)
  - Kings County, NY: 1.8 nm (3.3 km)
    - **TOTAL DISTANCE = 128.3 nm (237.6 km)**
- SBMT to center of Lease Area (each way):
  - Kings County, NY: 7.8 nm (14.5 km)
  - Queens County, NY: 3.0 nm (5.5 km)
  - Monmouth County, NJ: 2.7 nm (5.0 km)
  - Inside OCS radius: 30 nm (55.6 km)
    - **TOTAL DISTANCE = 43.5 nm (80.6 km)**

K.3.4 Submarine Export Cable Construction

Emissions from construction of the submarine export cable and export cable landfall for EW 1 and EW 2 will occur along an export cable route from the Lease Area to each onshore POI. A portion of each export cable route is located within 25 nm (46 km) of the Lease Area (and these construction emissions will be part of the OCS source potential to emit). The remainder of each cable route is located in New York state waters.

For all vessels used in construction of each submarine export cable, the air emissions were divided proportionally into each geographic area as follows:

- EW 1 export cable landfall to Lease Area (each way):
  - Kings County, NY: 8.0 nm (15 km)
  - Queens County, NY: 6.5 nm (12 km)
  - Inside OCS radius: 25.5 nm (47.2 km)
    - **TOTAL DISTANCE = 40.0 nm (74.1 km)**

- EW 2 export cable landfall to Lease Area (each way):
  - Nassau County, NY: 8.0 nm (15 km)
  - Inside OCS radius: 18.0 nm (33.3 km)
    - **TOTAL DISTANCE = 26.0 nm (48.3 km)**

K.3.5 All Other Vessel Activities

With the exception of transits to and from ports (such as SBMT, Port of Albany, Texas ports, and transits from overseas ports), and the portions of each submarine export cable route located in state waters, emissions from all other vessel activities were assumed to occur within 25 nm (46 km) of the Lease Area and are therefore part of the OCS source potential to emit. The activities listed above that are not part of the OCS source potential to emit are discussed for NEPA purposes only.

K.3.6 Helicopter Transits

For the purpose of allocating emissions to geographic areas, helicopter flights were treated in a similar manner to vessel transits, with all flights assumed to originate from JFK International Airport.

For the foundation and wind turbine generator installation tasks, distances were based on a straight-line route to the center of the Lease Area. Travel distances across each of the jurisdictional areas were calculated to be as follows:

- JFK International Airport to center of Lease Area (each way):
  - Queens County, NY: 1.5 statute miles (2.4 km)
  - Nassau County, NY: 8.5 statute miles (13.7 km)
  - Inside OCS radius: 20 statute miles (32.2 km)
    - **TOTAL DISTANCE = 30.0 statute miles (48.3 km)**

For the submarine export cable installation task, distances vary depending on which segment of the submarine export cable route is being visited. Travel distances for each export cable were estimated as follows:

- JFK International Airport to each submarine export cable route (each way):
  - For the EW 1 submarine export cable route, one-way distance was estimated to average 14 statute miles (22.5 km), varying from 10 to 24 statute miles (16.1 to 38.6 km), with total mileage distributions of 30% in Kings County, 27% in Queens County, 9% in Nassau County, and 34% inside the OCS radius.
  - For the EW 2 submarine export cable route, one-way distance was estimated to average 20 statute miles (32.2 km), varying from 8 to 32 statute miles (12.9 to 51.5 km), with total mileage distributions of 6% in Queens County, 41% in Nassau County, and 53% inside the OCS radius.

K.4 ONSHORE CONSTRUCTION AND OPERATION

Emissions from EW 1 and EW 2 for construction and operations of the O&M Base, onshore substation, onshore export cable, and interconnection cable will occur in the following geographic locations:

- EW 1: Kings County, New York (onshore substation, O&M Base (used by both EW 1 and EW 2), onshore staging and assembly of wind turbine generator components (used by both EW 1 and EW 2), onshore export cables, and interconnection cables); and
- EW 2: Nassau County, New York (onshore substation, onshore export cables, and interconnection cables).

K.5 DECOMMISSIONING

Emissions from the decommissioning of EW 1 and EW 2 have been assumed to occur in the same geographic locations as emissions from the construction of EW 1 and EW 2. Emissions have been assumed to include the same marine vessels and activities as construction. However, these steps would be performed in the reverse order.

The following equipment and/or activities were not included in the estimated decommissioning emissions:

- Seabed preparation vessels, such as fall pipe vessels and pre-trenching vessels;
- Bubble curtain vessels;
- Commissioning activities;
- Routine operation and maintenance activities were assumed to cease prior to the start of decommissioning; and
- All onshore facilities, including onshore substations, transmission cables, and the O&M Base, were assumed to either remain in use or be repurposed for other uses after the offshore facilities for EW 1 and EW 2 are decommissioned, and therefore it was assumed these facilities would not have any decommissioning emissions.

A full decommissioning plan will be submitted to BOEM for approval prior to any decommissioning activities, and potential impacts will be re-evaluated at that time.

K.6 SUMMARY OF EMISSIONS BY GEOGRAPHIC AREA

Potential emissions have been estimated for the construction, operations, maintenance, and decommissioning of both EW 1 and EW 2.

Under the construction schedule, construction of onshore facilities begins in 2023 for EW 1, and in 2024 for EW 2, followed by the commencement of construction for the EW 1 offshore facilities in 2024, and for the EW 2 offshore facilities in 2025, with EW 1 and EW 2 each having a total construction duration of four years. Construction emissions would begin in calendar year 2023 (start of EW 1) and continue through calendar year 2027 (completion of EW 2).

Emissions from operations and maintenance would begin as EW 1 was completed and would be concurrent with construction emissions from EW 2. It was assumed that the following tasks would occur in each year of activity:

- **Year 1:** Onshore substation construction (EW 1 only), and O&M Base construction (shared facility for both EW 1 and EW 2);

- **Year 2:** Onshore substation construction (EW 1 and EW 2), submarine export cable installation (EW 1 only), onshore export and interconnection cables (EW 1 and EW 2), and export cable landfall construction (EW 1 only);

- **Year 3:** Onshore substation construction (EW 1 and EW 2), wind turbine foundation installation (EW 1 and EW 2), submarine export cable installation (EW 1 and EW 2), interarray cable installation (EW 1 only), offshore substation topside and foundation installation (EW 1 and EW 2), wind turbine installation and offshore commissioning (EW 1 only), onshore export and interconnection cables (EW 1 and EW 2), and export cable landfall construction (EW 1 and EW 2);

- **Year 4:** Wind turbine foundation installation (EW 2 only), interarray cable installation (EW 2 only), offshore substation topside and foundation installation (EW 2 only), wind turbine installation and offshore commissioning (EW 1 and EW 2), and normal operations and maintenance (EW 1 only);

- **Year 5:** Wind turbine installation and offshore commissioning (EW 2 only), and normal operations and maintenance (EW 1 only); and

- **Year 6:** Normal operations and maintenance (EW 1 and EW 2).

Emissions from the decommissioning of EW 1 and EW 2 would occur following the end of the Project's useful lifetime. Since the schedule for decommissioning tasks is unknown at this time, only the total estimated emissions have been presented, rather than calendar year totals.

Table K-2 through **Table K-8** present the potential emissions for both EW 1 and EW 2, by calendar year for each geographic area considered. The emissions in each area include total emissions from construction (both onshore and offshore), from operations and maintenance, including vessel transits, and from decommissioning. Details on emissions for EW 1 and EW 2, individually and by construction activity, are presented in **Attachment K-1**.

Table K-2 Calendar Year 2023 Potential Emissions (tons)

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
South Carolina state waters (Charleston AQCR)	0	0	0	0	0	0	0	0
Texas state waters (Corpus Christi-Victoria AQCR)	0	0	0	0	0	0	0	0
Albany County, NY	0	0	0	0	0	0	0	0
Greene County, NY	0	0	0	0	0	0	0	0
Ulster County, NY	0	0	0	0	0	0	0	0
Orange County, NY	0	0	0	0	0	0	0	0
Rockland County, NY	0	0	0	0	0	0	0	0
Bergen County, NJ	0	0	0	0	0	0	0	0
Hudson County, NJ	0	0	0	0	0	0	0	0
Rensselaer County, NY	0	0	0	0	0	0	0	0
Columbia County, NY	0	0	0	0	0	0	0	0
Dutchess County, NY	0	0	0	0	0	0	0	0
Putnam County, NY	0	0	0	0	0	0	0	0
Westchester County, NY	0	0	0	0	0	0	0	0
Bronx County, NY	0	0	0	0	0	0	0	0
New York County, NY	0	0	0	0	0	0	0	0
Kings County, NY	0.10	0.69	0.25	0.03	0.03	1.58E-03	0.02	279.6
Queens County, NY	0	0	0	0	0	0	0	0
Monmouth County, NJ	0	0	0	0	0	0	0	0
Nassau County, NY	0	0	0	0	0	0	0	0
Ozone NAA (NY-NJ-CT)	0.10	0.69	--	--	--	--	--	--
PM_{10} NAA (New York County, NY)	--	--	--	0	--	--	--	--
$PM_{2.5}$ Maintenance Area (1997 Annual, NY-NJ-CT)	--	0.69	--	--	0.03	1.58E-03	--	--

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
$PM_{2.5}$ Maintenance Area (2006 24-hour, NY-NJ-CT)	--	0.69	--	--	0.03	1.58E-03	--	--
C0 Maintenance Area (NY-NJ-CT)	--	--	0.25	--	--	--	--	--
Federal waters outside OCS radius	0	0	0	0	0	0	0	0
Federal waters inside OCS radius	0	0	0	0	0	0	0	0
TOTAL, ALL AREAS	**0.10**	**0.69**	**0.25**	**0.03**	**0.03**	**1.58E-03**	**0.02**	**280**

Note:
a/ Total for all areas will differ from the subtotals shown above because it includes emissions for counties not subject to General Conformity, and also only counts emissions a single time for pollutants (such as NO_X and SO_2) that are precursors for more than one General Conformity pollutant.

Table K-3 Calendar Year 2024 Potential Emissions (tons)

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
South Carolina state waters (Charleston AQCR)	3.59	85.03	13.94	1.73	1.63	2.21	0.32	4,741.85
Texas state waters (Corpus Christi-Victoria AQCR)	0	0	0	0	0	0	0	0
Albany County, NY	0	0	0	0	0	0	0	0
Greene County, NY	0	0	0	0	0	0	0	0
Ulster County, NY	0	0	0	0	0	0	0	0
Orange County, NY	0	0	0	0	0	0	0	0
Rockland County, NY	0	0	0	0	0	0	0	0
Bergen County, NJ	0	0	0	0	0	0	0	0
Hudson County, NJ	0	0	0	0	0	0	0	0
Rensselaer County, NY	0	0	0	0	0	0	0	0
Columbia County, NY	0	0	0	0	0	0	0	0
Dutchess County, NY	0	0	0	0	0	0	0	0
Putnam County, NY	0	0	0	0	0	0	0	0
Westchester County, NY	0	0	0	0	0	0	0	0
Bronx County, NY	0	0	0	0	0	0	0	0
New York County, NY	0	0	0	0	0	0	0	0
Kings County, NY	10.97	279.78	54.36	5.38	5.07	6.28	1.06	18,078.1
Queens County, NY	3.14	60.33	39.80	2.32	2.24	0.16	0.30	5,757.3
Monmouth County, NJ	7.08E-04	0.02	1.48E-03	2.51E-04	2.31E-04	5.39E-04	6.20E-05	0.9
Nassau County, NY	1.46	40.42	9.32	1.85	1.79	0.03	0.24	3,908.9
Ozone NAA (NY-NJ-CT)	15.57	380.54	--	--	--	--	--	--
PM_{10} NAA (New York County, NY)	--	--	--	0	--	--	--	--
$PM_{2.5}$ Maintenance Area (1997 Annual, NY-NJ-CT)	--	380.54	--	--	9.11	6.47	--	--

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
$PM_{2.5}$ Maintenance Area (2006 24-hour, NY-NJ-CT)	--	380.54	--	--	9.11	6.47	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	103.48	--	--	--	--	--
Federal waters outside OCS radius	1.74	41.15	6.75	0.84	0.79	1.07	0.16	2,294.5
Federal waters inside OCS radius	7.38	161.14	74.77	4.32	4.15	1.90	0.68	13,165
TOTAL, ALL AREAS	**28.28**	**667.86**	**198.94**	**16.43**	**15.67**	**11.64**	**2.76**	**47,946**

Note:
a/ Total for all areas will differ from the subtotals shown above because it includes emissions for counties not subject to General Conformity, and also only counts emissions a single time for pollutants (such as NO_X and SO_2) that are precursors for more than one General Conformity pollutant.

Table K-4 Calendar Year 2025 Potential Emissions (tons)

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
South Carolina state waters (Charleston AQCR)	6.10	31.71	26.89	1.95	1.88	0.91	0.53	3,656.5
Texas state waters (Corpus Christi-Victoria AQCR)	0.21	0.32	0.55	0.02	0.02	0.04	0.02	73.8
Albany County, NY	1.44E-02	0.26	0.18	9.45E-03	9.16E-03	2.20E-04	1.36E-03	24.3
Greene County, NY	0.03	0.57	0.38	0.02	0.02	4.80E-04	2.97E-03	53.0
Ulster County, NY	0.05	0.84	0.57	0.03	0.03	7.09E-04	4.38E-03	78.2
Orange County, NY	0.02	0.45	0.30	0.02	0.02	3.81E-04	2.35E-03	42.0
Rockland County, NY	0.03	0.54	0.37	0.02	0.02	4.57E-04	2.82E-03	50.4
Bergen County, NJ	0.02	0.32	0.22	1.15E-02	1.12E-02	2.69E-04	1.66E-03	29.7
Hudson County, NJ	1.04E-02	0.19	0.13	6.81E-03	6.61E-03	1.59E-04	9.80E-04	17.5
Rensselaer County, NY	1.42E-02	0.26	0.17	9.26E-03	8.99E-03	2.16E-04	1.33E-03	23.8
Columbia County, NY	0.04	0.65	0.44	0.02	0.02	5.50E-04	3.40E-03	60.7
Dutchess County, NY	0.06	1.00	0.68	0.04	0.04	8.44E-04	5.22E-03	93.2
Putnam County, NY	1.14E-02	0.21	0.14	7.45E-03	7.22E-03	1.73E-04	1.07E-03	19.2
Westchester County, NY	0.04	0.68	0.46	0.02	0.02	5.71E-04	3.53E-03	63.1
Bronx County, NY	3.05E-03	0.06	0.04	2.00E-03	1.94E-03	4.65E-05	2.88E-04	5.1

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
New York County, NY	0.02	0.32	0.22	1.17E-02	1.14E-02	2.73E-04	1.69E-03	30.1
Kings County, NY	6.80	173.17	23.91	3.86	3.65	4.11	0.75	11,569.5
Queens County, NY	0.12	2.52	0.83	0.07	0.07	0.05	1.06E-02	189.2
Monmouth County, NJ	0.10	2.14	0.73	0.06	0.06	0.04	9.27E-03	148.9
Nassau County, NY	8.37	221.45	74.41	10.51	10.19	0.27	1.07	18,565.3
Ozone NAA (NY-NJ-CT)	15.50	401.37	--	--	--	--	--	--
PM_{10} NAA (New York County, NY)	--	--	--	1.17E-02	--	--	--	--
$PM_{2.5}$ Maintenance Area (1997 Annual, NY-NJ-CT)	--	401.83	--	--	14.06	4.46	--	--
$PM_{2.5}$ Maintenance Area (2006 24-hour, NY-NJ-CT)	--	401.83	--	--	14.06	4.46	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	100.20	--	--	--	--	--
Federal waters outside OCS radius	17.77	37.68	51.33	2.34	2.20	3.22	1.48	6,891.3
Federal waters inside OCS radius	145.76	1,821.86	688.33	51.04	48.41	44.59	12.78	138,960
TOTAL, ALL AREAS	**185.58**	**2,297.18**	**871.26**	**70.09**	**66.70**	**53.22**	**16.67**	**180,645**

Note:
a/ Total for all areas will differ from the subtotals shown above because it includes emissions for counties not subject to General Conformity, and also only counts emissions a single time for pollutants (such as NO_X and SO_2) that are precursors for more than one General Conformity pollutant.

Table K-5 Calendar Year 2026 Potential Emissions (tons)

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
South Carolina state waters (Charleston AQCR)	1.45	26.16	15.82	1.58	1.53	0.02	0.15	2,182.48
Texas state waters (Corpus Christi-Victoria AQCR)	0.07	0.11	0.18	6.70E-03	6.19E-03	1.33E-02	5.84E-03	24.62
Albany County, NY	0.06	1.11	0.75	0.04	0.04	9.38E-04	5.80E-03	103.55
Greene County, NY	0.13	2.42	1.64	0.09	0.09	2.05E-03	1.26E-02	226.01
Ulster County, NY	0.20	3.58	2.42	0.13	0.13	3.02E-03	0.02	333.53
Orange County, NY	0.11	1.92	1.30	0.07	0.07	1.62E-03	1.00E-02	179.21
Rockland County, NY	0.13	2.31	1.56	0.08	0.08	1.95E-03	1.20E-02	215.06
Bergen County, NJ	0.08	1.36	0.92	0.05	0.05	1.15E-03	7.08E-03	126.44
Hudson County, NJ	0.04	0.80	0.54	0.03	0.03	6.76E-04	4.18E-03	74.67
Rensselaer County, NY	0.06	1.09	0.74	0.04	0.04	9.20E-04	5.68E-03	101.55
Columbia County, NY	0.15	2.78	1.88	0.10	0.10	2.34E-03	1.45E-02	258.86
Dutchess County, NY	0.24	4.26	2.88	0.15	0.15	3.60E-03	0.02	397.25
Putnam County, NY	0.05	0.88	0.59	0.03	0.03	7.39E-04	4.57E-03	81.64
Westchester County, NY	0.16	2.88	1.95	0.10	0.10	2.43E-03	0.02	268.82
Bronx County, NY	1.30E-02	0.23	0.16	8.52E-03	8.26E-03	1.98E-04	1.23E-03	21.90
New York County, NY	0.08	1.38	0.93	0.05	0.05	1.16E-03	7.19E-03	128.44
Kings County, NY	1.58	18.92	14.97	0.77	0.74	0.09	0.23	3,805.00
Queens County, NY	0.24	4.30	2.71	0.17	0.17	0.03	0.02	411.40
Monmouth County, NJ	0.22	3.84	2.44	0.16	0.15	0.02	0.02	363.85
Nassau County, NY	0.02	0.21	4.93E-03	4.81E-03	4.81E-03	1.27E-02	4.16E-04	40.36
Ozone NAA (NY-NJ-CT)	2.55	36.22	--	--	--	--	--	--
PM_{10} NAA (New York County, NY)	--	--	--	0.05	--	--	--	--
$PM_{2.5}$ Maintenance Area (1997 Annual, NY-NJ-CT)	--	38.15	--	--	1.45	0.16	--	--

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
$PM_{2.5}$ Maintenance Area (2006 24-hour, NY-NJ-CT)	--	38.15	--	--	1.45	0.16	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	22.19	--	--	--	--	--
Federal waters outside OCS radius	5.28	19.65	19.56	1.20	1.14	0.87	0.45	2,647.9
Federal waters inside OCS radius	126.21	1,806.79	833.29	56.27	53.83	33.31	11.30	149,397
TOTAL, ALL AREAS	**136.56**	**1,906.96**	**907.23**	**61.14**	**58.53**	**34.39**	**12.32**	**161,389**

Note:
a/ Total for all areas will differ from the subtotals shown above because it includes emissions for counties not subject to General Conformity, and also only counts emissions a single time for pollutants (such as NO_X and SO_2) that are precursors for more than one General Conformity pollutant.

Table K-6 Calendar Year 2027 Potential Emissions (tons)

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
South Carolina state waters (Charleston AQCR)	0	0	0	0	0	0	0	0
Texas state waters (Corpus Christi-Victoria AQCR)	0	0	0	0	0	0	0	0
Albany County, NY	0.07	1.32	0.89	0.05	0.05	1.11E-03	6.87E-03	122.7
Greene County, NY	0.16	2.87	1.94	0.10	0.10	2.43E-03	1.50E-02	267.9
Ulster County, NY	0.23	4.24	2.87	0.15	0.15	3.58E-03	0.02	395.3
Orange County, NY	0.13	2.28	1.54	0.08	0.08	1.92E-03	1.19E-02	212.4
Rockland County, NY	0.15	2.73	1.85	0.10	0.10	2.31E-03	1.43E-02	254.9
Bergen County, NJ	0.09	1.61	1.09	0.06	0.06	1.36E-03	8.39E-03	149.9
Hudson County, NJ	0.05	0.95	0.64	0.03	0.03	8.02E-04	4.95E-03	88.5
Rensselaer County, NY	0.07	1.29	0.87	0.05	0.05	1.09E-03	6.74E-03	120.4
Columbia County, NY	0.18	3.29	2.22	0.12	0.12	2.78E-03	0.02	306.8
Dutchess County, NY	0.28	5.05	3.41	0.18	0.18	4.26E-03	0.03	470.8
Putnam County, NY	0.06	1.04	0.70	0.04	0.04	8.76E-04	5.42E-03	96.8
Westchester County, NY	0.19	3.42	2.31	0.12	0.12	2.89E-03	0.02	318.6
Bronx County, NY	0.02	0.28	0.19	1.01E-02	9.79E-03	2.35E-04	1.45E-03	26.0
New York County, NY	0.09	1.63	1.10	0.06	0.06	1.38E-03	8.52E-03	152.2
Kings County, NY	1.55	18.49	17.10	0.79	0.77	0.03	0.21	3,851.8
Queens County, NY	0.27	4.27	3.89	0.19	0.19	7.84E-03	0.03	544.0
Monmouth County, NJ	0.24	3.81	3.50	0.17	0.17	5.12E-03	0.02	483.4
Nassau County, NY	0.13	2.21	1.16	0.07	0.07	1.44E-02	2.64E-03	1,690.7
Ozone NAA (NY-NJ-CT)	2.79	39.41	--	--	--	--	--	--
PM_{10} NAA (New York County, NY)	--	--	--	0.06	--	--	--	--
$PM_{2.5}$ Maintenance Area (1997 Annual, NY-NJ-CT)	--	41.69	--	--	1.65	0.07	--	--

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
$PM_{2.5}$ Maintenance Area (2006 24-hour, NY-NJ-CT)	--	41.69	--	--	1.65	0.07	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	27.48	--	--	--	--	--
Federal waters outside OCS radius	0	0	0	0	0	0	0	0
Federal waters inside OCS radius	74.42	640.28	625.21	25.55	24.61	8.27	6.49	88,300
TOTAL, ALL AREAS	**78.39**	**701.06**	**672.48**	**27.94**	**26.92**	**8.35**	**6.92**	**97,853**

Note:
a/ Total for all areas will differ from the subtotals shown above because it includes emissions for counties not subject to General Conformity, and also only counts emissions a single time for pollutants (such as NO_X and SO_2) that are precursors for more than one General Conformity pollutant.

Table K-7 Calendar Year 2028 and Onward Potential Emissions (tons per year)

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
Kings County, NY	0.43	4.58	6.47	0.15	0.14	0.02	0.04	1,791.9
Queens County, NY	0.08	0.78	1.74	0.02	0.02	3.84E-03	6.48E-03	242.1
Monmouth County, NJ	0.07	0.70	1.57	0.02	0.02	3.46E-03	5.83E-03	217.9
Nassau County, NY	0.11	2.01	1.16	0.07	0.06	2.18E-03	2.24E-03	1,651.9
Ozone NAA (NY-NJ-CT)	0.69	8.07	--	--	--	--	--	--
PM_{10} NAA (New York County, NY)	--	--	--	0	--	--	--	--
$PM_{2.5}$ Maintenance Area (1997 Annual, NY-NJ-CT)	--	8.07	--	--	0.24	0.02	--	--
$PM_{2.5}$ Maintenance Area (2006 24-hour, NY-NJ-CT)	--	8.07	--	--	0.24	0.02	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	0.25	--	--	--	--	--
Federal waters outside OCS radius	0	0	0	0	0	0	0	0
Federal waters inside OCS radius	18.97	178.68	234.71	6.06	5.83	2.39	1.62	35,237
TOTAL, ALL AREAS	**19.65**	**186.75**	**245.64**	**6.31**	**6.08**	**2.41**	**1.68**	**39,141**

Note:
a/ Total for all areas will differ from the subtotals shown above because it includes emissions for counties not subject to General Conformity, and also only counts emissions a single time for pollutants (such as NO_X and SO_2) that are precursors for more than one General Conformity pollutant.

Table K-8 Decommissioning Potential Emissions (tons)

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
South Carolina state waters (Charleston AQCR)	0	0	0	0	0	0	0	0
Texas state waters (Corpus Christi-Victoria AQCR)	0.06	0.09	0.15	5.36E-03	4.95E-03	1.06E-02	4.67E-03	19.7
Albany County, NY	0.03	0.54	0.36	0.02	0.02	4.54E-04	2.80E-03	50.1
Greene County, NY	0.07	1.17	0.79	0.04	0.04	9.91E-04	6.12E-03	109.4
Ulster County, NY	0.10	1.73	1.17	0.06	0.06	1.46E-03	9.03E-03	161.4
Orange County, NY	0.05	0.93	0.63	0.03	0.03	7.86E-04	4.85E-03	86.7
Rockland County, NY	0.06	1.12	0.75	0.04	0.04	9.43E-04	5.82E-03	104.1
Bergen County, NJ	0.04	0.66	0.44	0.02	0.02	5.54E-04	3.42E-03	61.2
Hudson County, NJ	0.02	0.39	0.26	1.41E-02	1.36E-02	3.27E-04	2.02E-03	36.1
Rensselaer County, NY	0.03	0.53	0.36	0.02	0.02	4.45E-04	2.75E-03	49.1
Columbia County, NY	0.07	1.34	0.91	0.05	0.05	1.13E-03	7.01E-03	125.3
Dutchess County, NY	0.11	2.06	1.39	0.07	0.07	1.74E-03	1.08E-02	192.3
Putnam County, NY	0.02	0.42	0.29	0.02	1.49E-02	3.58E-04	2.21E-03	39.5
Westchester County, NY	0.08	1.40	0.94	0.05	0.05	1.18E-03	7.28E-03	130.1
Bronx County, NY	6.30E-03	0.11	0.08	4.12E-03	4.00E-03	9.60E-05	5.93E-04	10.6
New York County, NY	0.04	0.67	0.45	0.02	0.02	5.63E-04	3.48E-03	62.2
Kings County, NY	0.65	10.67	5.84	0.45	0.44	0.04	0.08	1,115.0
Queens County, NY	1.14	19.78	14.54	0.78	0.75	0.03	0.11	2,013.9
Monmouth County, NJ	0.13	1.58	0.97	0.09	0.08	9.71E-03	1.23E-02	134.0
Nassau County, NY	0.94	14.47	9.81	0.77	0.74	0.02	0.12	1,618.1
Ozone NAA (NY-NJ-CT)	3.10	50.84	--	--	--	--	--	--
PM_{10} NAA (New York County, NY)	--	--	--	0.02	--	--	--	--
$PM_{2.5}$ Maintenance Area (1997 Annual, NY-NJ-CT)	--	51.77	--	--	2.20	0.10	--	--

Geographic Area	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
$PM_{2.5}$ Maintenance Area (2006 24-hour, NY-NJ-CT)	--	51.77	--	--	2.20	0.10	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	32.37	--	--	--	--	--
Federal waters outside OCS radius	18.30	27.98	47.62	1.73	1.60	3.43	1.51	6,367.1
Federal waters inside OCS radius	53.63	500.50	234.44	18.02	17.17	13.46	4.69	41,352.1
TOTAL, ALL AREAS	**75.57**	**588.13**	**322.20**	**22.31**	**21.25**	**17.01**	**6.59**	**53,838**

Note:
a/ Total for all areas will differ from the subtotals shown above because it includes emissions for counties not subject to General Conformity, and also only counts emissions a single time for pollutants (such as NO_X and SO_2) that are precursors for more than one General Conformity pollutant.

K.7 REFERENCES

BOEM (Bureau of Offshore Energy Management). 2017. *BOEM Offshore Wind Energy Facilities Emission Estimating Tool – Technical Documentation*. U.S. Department of the Interior. BOEM Office of Renewable Energy Programs. Available online at: https://www.boem.gov/sites/default/files/renewable-energy-program/BOEM-Wind-Power-Technical-Documentation_2017_079-%281%29.pdf.

EPA (U.S. Environmental Protection Agency). 1996. Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Section 3.3 Gasoline and Diesel Industrial Engines, AP-42, October 1996.

EPA. 2005. EPA's National Inventory Model (NMIM), A Consolidated Emissions Modeling System for MOBILE6 and NONROAD. Available online at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10023FZ.txt. Accessed December 17, 2019.

EPA. 2010. *Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling*. EPA Office of Air and Radiation Report No. NR-005d. Revised July 2010. Available online at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10081RV.txt. Accessed December 17, 2019.

EPA. 2014. MOVES (Motor Vehicle Emission Simulator). Available online at: https://www.epa.gov/moves.

EPA. 2016. Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance, EPA430-K-16-004, January 2016.

EPA. 2017. "SF_6 Leak Rates from High Voltage Circuit Breakers - U.S. EPA Investigates Potential Greenhouse Gas Emissions Source." Available online at: https://www.epa.gov/sites/production/files/2016-02/documents/leakrates_circuitbreakers.pdf. Accessed December 17, 2019.

EPA. 2022. *Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions*, EPA-420-B-22-011, April 2022.

ATTACHMENT K-1
EMISSION CALCULATIONS

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2)

ATTACHMENT K-1: LIST OF TABLES

ATTACHMENT K-1: Glossary of Terms

Transit: Transit refers to periods when marine vessels are traveling to and from the OCS source.
Non-Transit: Non-Transit refers to periods when marine vessels are performing a construction-related task other than traveling to and from the OCS source.
Total Emissions (Non-Transit): This represents the total estimated emissions from a given vessel or engine that will be produced for the non-transit portions of the entire construction task.
Total Emissions (Transit): This represents the total estimated emissions from a given vessel or engine that will be produced for the transit portions of the entire construction task.
OCS radius: This refers to the line that is located at a distance of 25 nautical miles from the Project lease area boundary.
Inside and Outside OCS radius: "Inside the OCS radius" refers to activities that occur within 25 nautical miles from the Project lease area boundary; "Outside the OCS radius" refers to activities that occur beyond 25 nautical miles from the Project lease area boundary.
Transit round-trip: This refers to a single vessel trip from a port to the Project lease area, and then back to the original port.
Non-OCS operating days: This refers to the number of days that a non-transit construction task is performed, which is located beyond 25 nautical miles from the Project lease area boundary.
OCS operating days: This refers to the number of days that a non-transit construction task is performed, which is located within 25 nautical miles from the Project lease area boundary.
Non-transit operating hours: This refers to the total number of operating hours that a given vessel or engine will perform a non-transit construction task, across the entire period of construction task, including activities both inside and outside the OCS radius.
DP: This indicates that a vessel uses dynamic positioning to hold its position at a construction site.
Anchored: This indicates that a vessel uses anchors to hold its position at a construction site.
Spud: This indicates that a vessel uses jack-up legs to hold its position at a construction site.
Emergency Engine: This indicates that the specification sheet for a representative vessel describes a particular engine as an emergency engine. Emergency engines on marine vessels are assumed to be marine engines, and are not assumed to be subject to stationary source emission standards, such as those for emergency generator engines in 40 CFR 60 Subpart IIII.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-1. Calendar Year Emission Summary

2023 (Construction of EW 1 and EW 2)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Texas state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Greene County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulster County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Orange County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Rockland County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bergen County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Rensselaer County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbia County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Dutchess County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Putnam County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Westchester County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bronx County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
New York County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Kings County, NY	0.10	0.69	0.25	0.03	0.03	1.58E-03	0.02	0.00E+00	5.43E-05	277.5	1.08E-02	6.29E-03	279.6
Queens County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Monmouth County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Nassau County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal/state waters inside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Ozone NAA (NY-NJ-CT)	**0.10**	**0.69**	--	--	--	--	--	--	--	--	--	--	--
PM10 NAA (New York County)	--	--	--	**0**	--	--	--	--	--	--	--	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	**0.25**	--	--	--	--	--	--	--	--	--	--
PM2.5 Maintenance Area (1997 Annual, NY-NJ-CT)	--	**0.69**	--	--	**0.03**	**1.58E-03**	--	--	--	--	--	--	--
PM2.5 Maintenance Area (2006 24-hour, NY-NJ-CT)	--	**0.69**	--	--	**0.03**	**1.58E-03**	--	--	--	--	--	--	--
TOTAL, ALL AREAS	**0.10**	**0.69**	**0.25**	**0.03**	**0.03**	**1.58E-03**	**0.02**	**0**	**5.43E-05**	**277**	**1.08E-02**	**6.29E-03**	**280**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-1. Calendar Year Emission Summary

2024 (Construction of EW 1 and EW 2)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	3.59	85.03	13.94	1.73	1.63	2.21	0.32	2.04E-04	0.08	4,677.07	0.07	0.21	4,741.85
Texas state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Greene County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulster County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Orange County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Rockland County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bergen County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Rensselaer County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbia County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Dutchess County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Putnam County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Westchester County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bronx County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
New York County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Kings County, NY	10.97	279.78	54.36	5.38	5.07	6.28	1.06	6.16E-04	0.22	17,837.4	0.27	0.79	18,078.1
Queens County, NY	3.14	60.33	39.80	2.32	2.24	0.16	0.30	2.80E-04	5.49E-03	5,673.0	0.08	0.28	5,757.3
Monmouth County, NJ	7.08E-04	0.02	1.48E-03	2.51E-04	2.31E-04	5.39E-04	6.20E-05	2.89E-08	1.85E-05	0.9	1.34E-05	3.90E-05	0.9
Nassau County, NY	1.46	40.42	9.32	1.85	1.79	0.03	0.24	2.00E-04	1.08E-03	3,862.2	0.07	0.15	3,908.9
Federal waters outside OCS radius	**1.74**	**41.15**	**6.75**	**0.84**	**0.79**	**1.07**	**0.16**	**9.86E-05**	**0.04**	**2,263.2**	**0.03**	**0.10**	**2,294.5**
Federal waters inside OCS radius	**7.38**	**161.14**	**74.77**	**4.32**	**4.15**	**1.90**	**0.68**	**5.18E-04**	**0.07**	**12,976**	**0.18**	**0.62**	**13,165**
Ozone NAA (NY-NJ-CT)	**15.57**	**380.54**	--	--	--	--	--	--	--	--	--	--	--
PM10 NAA (New York County)	--	--	--	**0**	--	--	--	--	--	--	--	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	**103.48**	--	--	--	--	--	--	--	--	--	--
PM2.5 Maintenance Area (1997 Annual, NY-NJ-CT)	--	**380.54**	--	--	**9.11**	**6.47**	--	--	--	--	--	--	--
PM2.5 Maintenance Area (2006 24-hour, NY-NJ-CT)	--	**380.54**	--	--	**9.11**	**6.47**	--	--	--	--	--	--	--
TOTAL, ALL AREAS	**28.28**	**667.86**	**198.94**	**16.43**	**15.67**	**11.64**	**2.76**	**1.92E-03**	**0.40**	**47,290**	**0.70**	**2.15**	**47,946**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-1. Calendar Year Emission Summary

2025 (Construction of EW 1 and EW 2)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	6.10	31.71	26.89	1.95	1.88	0.91	0.53	2.34E-04	0.03	3,604.7	0.05	0.17	3,656.5
Texas state waters	0.21	0.32	0.55	0.02	0.02	0.04	0.02	2.32E-06	1.37E-03	72.8	1.10E-03	3.25E-03	73.8
Albany County, NY	1.44E-02	0.26	0.18	9.45E-03	9.16E-03	2.20E-04	1.36E-03	1.15E-06	7.57E-06	23.9	3.51E-04	1.17E-03	24.3
Greene County, NY	0.03	0.57	0.38	0.02	0.02	4.80E-04	2.97E-03	2.50E-06	1.65E-05	52.2	7.65E-04	2.55E-03	53.0
Ulster County, NY	0.05	0.84	0.57	0.03	0.03	7.09E-04	4.38E-03	3.69E-06	2.44E-05	77.1	1.13E-03	3.77E-03	78.2
Orange County, NY	0.02	0.45	0.30	0.02	0.02	3.81E-04	2.35E-03	1.98E-06	1.31E-05	41.4	6.07E-04	2.03E-03	42.0
Rockland County, NY	0.03	0.54	0.37	0.02	0.02	4.57E-04	2.82E-03	2.38E-06	1.57E-05	49.7	7.28E-04	2.43E-03	50.4
Bergen County, NJ	0.02	0.32	0.22	1.15E-02	1.12E-02	2.69E-04	1.66E-03	1.40E-06	9.24E-06	29.2	4.28E-04	1.43E-03	29.7
Hudson County, NJ	1.04E-02	0.19	0.13	6.81E-03	6.61E-03	1.59E-04	9.80E-04	8.26E-07	5.46E-06	17.3	2.53E-04	8.44E-04	17.5
Rensselaer County, NY	1.42E-02	0.26	0.17	9.26E-03	8.99E-03	2.16E-04	1.33E-03	1.12E-06	7.42E-06	23.5	3.44E-04	1.15E-03	23.8
Columbia County, NY	0.04	0.65	0.44	0.02	0.02	5.50E-04	3.40E-03	2.86E-06	1.89E-05	59.8	8.76E-04	2.93E-03	60.7
Dutchess County, NY	0.06	1.00	0.68	0.04	0.04	8.44E-04	5.22E-03	4.39E-06	2.90E-05	91.8	1.34E-03	4.49E-03	93.2
Putnam County, NY	1.14E-02	0.21	0.14	7.45E-03	7.22E-03	1.73E-04	1.07E-03	9.03E-07	5.97E-06	18.9	2.76E-04	9.23E-04	19.2
Westchester County, NY	0.04	0.68	0.46	0.02	0.02	5.71E-04	3.53E-03	2.97E-06	1.97E-05	62.1	9.10E-04	3.04E-03	63.1
Bronx County, NY	3.05E-03	0.06	0.04	2.00E-03	1.94E-03	4.65E-05	2.88E-04	2.42E-07	1.60E-06	5.1	7.42E-05	2.48E-04	5.1
New York County, NY	0.02	0.32	0.22	1.17E-02	1.14E-02	2.73E-04	1.69E-03	1.42E-06	9.39E-06	29.7	4.35E-04	1.45E-03	30.1
Kings County, NY	6.80	173.17	23.91	3.86	3.65	4.11	0.75	4.28E-04	0.14	11,427.6	0.23	0.46	11,569.5
Queens County, NY	0.12	2.52	0.83	0.07	0.07	0.05	1.06E-02	8.12E-06	1.64E-03	186.6	2.90E-03	8.48E-03	189.2
Monmouth County, NJ	0.10	2.14	0.73	0.06	0.06	0.04	9.27E-03	7.07E-06	1.27E-03	146.8	2.05E-03	6.90E-03	148.9
Nassau County, NY	8.37	221.45	74.41	10.51	10.19	0.27	1.07	1.22E-03	9.21E-03	18,315.8	0.25	0.82	18,565.3
Federal waters outside OCS radius	**17.77**	**37.68**	**51.33**	**2.34**	**2.20**	**3.22**	**1.48**	**2.75E-04**	**0.11**	**6,797.2**	**0.10**	**0.31**	**6,891.3**
Federal waters inside OCS radius	**145.76**	**1,821.86**	**688.33**	**51.04**	**48.41**	**44.59**	**12.78**	**6.05E-03**	**1.53**	**137,022**	**1.86**	**6.35**	**138,960**
Ozone NAA (NY-NJ-CT)	**15.50**	**401.37**	--	--	--	--	--	--	--	--	--	--	--
PM10 NAA (New York County)	--	--	--	**1.17E-02**	--	--	--	--	--	--	--	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	**100.20**	--	--	--	--	--	--	--	--	--	--
PM2.5 Maintenance Area (1997 Annual, NY-NJ-CT)	--	**401.83**	--	--	**14.06**	**4.46**	--	--	--	--	--	--	--
PM2.5 Maintenance Area (2006 24-hour, NY-NJ-CT)	--	**401.83**	--	--	**14.06**	**4.46**	--	--	--	--	--	--	--
TOTAL, ALL AREAS	**185.58**	**2,297.18**	**871.26**	**70.09**	**66.70**	**53.22**	**16.67**	**8.25E-03**	**1.83**	**178,155**	**2.50**	**8.14**	**180,645**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-1. Calendar Year Emission Summary

2026 (Construction of EW 1 and EW 2, plus EW 1 O&M)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	1.45	26.16	15.82	1.58	1.53	0.02	0.15	1.92E-04	6.80E-04	2,150.4	0.03	0.11	2,182.48
Texas state waters	0.07	0.11	0.18	6.70E-03	6.19E-03	1.33E-02	5.84E-03	7.74E-07	4.56E-04	24.3	3.68E-04	1.08E-03	24.62
Albany County, NY	0.06	1.11	0.75	0.04	0.04	9.38E-04	5.80E-03	4.88E-06	3.23E-05	102.0	1.49E-03	4.99E-03	103.55
Greene County, NY	0.13	2.42	1.64	0.09	0.09	2.05E-03	1.26E-02	1.07E-05	7.04E-05	222.7	3.26E-03	1.09E-02	226.01
Ulster County, NY	0.20	3.58	2.42	0.13	0.13	3.02E-03	0.02	1.57E-05	1.04E-04	328.6	4.81E-03	0.02	333.53
Orange County, NY	0.11	1.92	1.30	0.07	0.07	1.62E-03	1.00E-02	8.45E-06	5.58E-05	176.6	2.59E-03	8.63E-03	179.21
Rockland County, NY	0.13	2.31	1.56	0.08	0.08	1.95E-03	1.20E-02	1.01E-05	6.70E-05	211.9	3.10E-03	1.04E-02	215.06
Bergen County, NJ	0.08	1.36	0.92	0.05	0.05	1.15E-03	7.08E-03	5.96E-06	3.94E-05	124.6	1.83E-03	6.09E-03	126.44
Hudson County, NJ	0.04	0.80	0.54	0.03	0.03	6.76E-04	4.18E-03	3.52E-06	2.33E-05	73.6	1.08E-03	3.60E-03	74.67
Rensselaer County, NY	0.06	1.09	0.74	0.04	0.04	9.20E-04	5.68E-03	4.79E-06	3.16E-05	100.1	1.47E-03	4.89E-03	101.55
Columbia County, NY	0.15	2.78	1.88	0.10	0.10	2.34E-03	1.45E-02	1.22E-05	8.07E-05	255.1	3.74E-03	1.25E-02	258.86
Dutchess County, NY	0.24	4.26	2.88	0.15	0.15	3.60E-03	0.02	1.87E-05	1.24E-04	391.4	5.73E-03	0.02	397.25
Putnam County, NY	0.05	0.88	0.59	0.03	0.03	7.39E-04	4.57E-03	3.85E-06	2.54E-05	80.4	1.18E-03	3.93E-03	81.64
Westchester County, NY	0.16	2.88	1.95	0.10	0.10	2.43E-03	0.02	1.27E-05	8.38E-05	264.9	3.88E-03	1.30E-02	268.82
Bronx County, NY	1.30E-02	0.23	0.16	8.52E-03	8.26E-03	1.98E-04	1.23E-03	1.03E-06	6.83E-06	21.6	3.16E-04	1.06E-03	21.90
New York County, NY	0.08	1.38	0.93	0.05	0.05	1.16E-03	7.19E-03	6.06E-06	4.00E-05	126.5	1.85E-03	6.19E-03	128.44
Kings County, NY	1.58	18.92	14.97	0.77	0.74	0.09	0.23	6.45E-05	2.94E-03	3,219.3	0.14	0.10	3,805.00
Queens County, NY	0.24	4.30	2.71	0.17	0.17	0.03	0.02	2.09E-05	9.91E-04	405.4	5.59E-03	0.02	411.40
Monmouth County, NJ	0.22	3.84	2.44	0.16	0.15	0.02	0.02	1.88E-05	8.22E-04	358.6	4.85E-03	0.02	363.85
Nassau County, NY	0.02	0.21	4.93E-03	4.81E-03	4.81E-03	1.27E-02	4.16E-04	2.01E-07	4.37E-04	39.9	1.14E-03	1.32E-03	40.36
Federal waters outside OCS radius	**5.28**	**19.65**	**19.56**	**1.20**	**1.14**	**0.87**	**0.45**	**1.43E-04**	**0.03**	**2,610.8**	**0.04**	**0.12**	**2,647.9**
Federal waters inside OCS radius	**126.21**	**1,806.79**	**833.29**	**56.27**	**53.83**	**33.31**	**11.30**	**6.72E-03**	**1.15**	**146,973**	**2.01**	**6.89**	**149,397**
Ozone NAA (NY-NJ-CT)	**2.55**	**36.22**	--	--	--	--	--	--	--	--	--	--	--
PM10 NAA (New York County)	--	--	--	**0.05**	--	--	--	--	--	--	--	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	**22.19**	--	--	--	--	--	--	--	--	--	--
PM2.5 Maintenance Area (1997 Annual, NY-NJ-CT)	--	**38.15**	--	--	**1.45**	**0.16**	--	--	--	--	--	--	--
PM2.5 Maintenance Area (2006 24-hour, NY-NJ-CT)	--	**38.15**	--	--	**1.45**	**0.16**	--	--	--	--	--	--	--
TOTAL, ALL AREAS	**136.56**	**1,906.96**	**907.23**	**61.14**	**58.53**	**34.39**	**12.32**	**7.28E-03**	**1.18**	**158,262**	**2.27**	**7.37**	**161,389**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-1. Calendar Year Emission Summary

2027 (Construction of EW 2, plus EW 1 O&M)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Texas state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany County, NY	0.07	1.32	0.89	0.05	0.05	1.11E-03	6.87E-03	5.79E-06	3.82E-05	120.9	1.77E-03	5.91E-03	122.7
Greene County, NY	0.16	2.87	1.94	0.10	0.10	2.43E-03	1.50E-02	1.26E-05	8.35E-05	263.9	3.87E-03	1.29E-02	267.9
Ulster County, NY	0.23	4.24	2.87	0.15	0.15	3.58E-03	0.02	1.86E-05	1.23E-04	389.5	5.71E-03	0.02	395.3
Orange County, NY	0.13	2.28	1.54	0.08	0.08	1.92E-03	1.19E-02	1.00E-05	6.62E-05	209.3	3.07E-03	1.02E-02	212.4
Rockland County, NY	0.15	2.73	1.85	0.10	0.10	2.31E-03	1.43E-02	1.20E-05	7.94E-05	251.1	3.68E-03	1.23E-02	254.9
Bergen County, NJ	0.09	1.61	1.09	0.06	0.06	1.36E-03	8.39E-03	7.07E-06	4.67E-05	147.7	2.16E-03	7.22E-03	149.9
Hudson County, NJ	0.05	0.95	0.64	0.03	0.03	8.02E-04	4.95E-03	4.17E-06	2.76E-05	87.2	1.28E-03	4.26E-03	88.5
Rensselaer County, NY	0.07	1.29	0.87	0.05	0.05	1.09E-03	6.74E-03	5.68E-06	3.75E-05	118.6	1.74E-03	5.80E-03	120.4
Columbia County, NY	0.18	3.29	2.22	0.12	0.12	2.78E-03	0.02	1.45E-05	9.56E-05	302.3	4.43E-03	1.48E-02	306.8
Dutchess County, NY	0.28	5.05	3.41	0.18	0.18	4.26E-03	0.03	2.22E-05	1.47E-04	463.9	6.80E-03	0.02	470.8
Putnam County, NY	0.06	1.04	0.70	0.04	0.04	8.76E-04	5.42E-03	4.56E-06	3.02E-05	95.3	1.40E-03	4.66E-03	96.8
Westchester County, NY	0.19	3.42	2.31	0.12	0.12	2.89E-03	0.02	1.50E-05	9.93E-05	313.9	4.60E-03	0.02	318.6
Bronx County, NY	0.02	0.28	0.19	1.01E-02	9.79E-03	2.35E-04	1.45E-03	1.22E-06	8.09E-06	25.6	3.75E-04	1.25E-03	26.0
New York County, NY	0.09	1.63	1.10	0.06	0.06	1.38E-03	8.52E-03	7.18E-06	4.74E-05	150.0	2.20E-03	7.33E-03	152.2
Kings County, NY	1.55	18.49	17.10	0.79	0.77	0.03	0.21	7.20E-05	9.99E-04	3,262.9	0.13	0.11	3,851.8
Queens County, NY	0.27	4.27	3.89	0.19	0.19	7.84E-03	0.03	2.32E-05	2.70E-04	536.0	7.15E-03	0.03	544.0
Monmouth County, NJ	0.24	3.81	3.50	0.17	0.17	5.12E-03	0.02	2.09E-05	1.76E-04	476.3	6.26E-03	0.02	483.4
Nassau County, NY	0.13	2.21	1.16	0.07	0.07	1.44E-02	2.64E-03	1.28E-06	4.95E-04	267.9	1.04E-02	3.13E-03	1,690.7
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal waters inside OCS radius	**74.42**	**640.28**	**625.21**	**25.55**	**24.61**	**8.27**	**6.49**	**3.07E-03**	**0.28**	**85,652**	**1.18**	**4.04**	**88,300**
Ozone NAA (NY-NJ-CT)	**2.79**	**39.41**	--	--	--	--	--	--	--	--	--	--	--
PM10 NAA (New York County)	--	--	--	**0.06**	--	--	--	--	--	--	--	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	**27.48**	--	--	--	--	--	--	--	--	--	--
PM2.5 Maintenance Area (1997 Annual, NY-NJ-CT)	--	**41.69**	--	--	**1.65**	**0.07**	--	--	--	--	--	--	--
PM2.5 Maintenance Area (2006 24-hour, NY-NJ-CT)	--	**41.69**	--	--	**1.65**	**0.07**	--	--	--	--	--	--	--
TOTAL, ALL AREAS	**78.39**	**701.06**	**672.48**	**27.94**	**26.92**	**8.35**	**6.92**	**3.33E-03**	**0.29**	**93,135**	**1.37**	**4.35**	**97,853**

2028 Onward (O&M for EW 1 and EW 2)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
Kings County, NY	0.43	4.58	6.47	0.15	0.14	0.02	0.04	7.49E-06	5.21E-04	1,225.9	0.05	0.04	1,791.9
Queens County, NY	0.08	0.78	1.74	0.02	0.02	3.84E-03	6.48E-03	2.52E-06	1.32E-04	238.6	2.91E-03	1.17E-02	242.1
Monmouth County, NJ	0.07	0.70	1.57	0.02	0.02	3.46E-03	5.83E-03	2.27E-06	1.19E-04	214.7	2.62E-03	1.05E-02	217.9
Nassau County, NY	0.11	2.01	1.16	0.07	0.06	2.18E-03	2.24E-03	1.08E-06	7.52E-05	229.5	9.31E-03	1.86E-03	1,651.9
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal waters inside OCS radius	**18.97**	**178.68**	**234.71**	**6.06**	**5.83**	**2.39**	**1.62**	**7.28E-04**	**0.08**	**33,354**	**0.49**	**1.53**	**35,237**
Ozone NAA (NY-NJ-CT)	**0.69**	**8.07**	--	--	--	--	--	--	--	--	--	--	--
PM10 NAA (New York County)	--	--	--	**0.00E+00**	--	--	--	--	--	--	--	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	**0.25**	--	--	--	--	--	--	--	--	--	--
PM2.5 Maintenance Area (1997 Annual, NY-NJ-CT)	--	**8.07**	--	--	**0.24**	**0.02**	--	--	--	--	--	--	--
PM2.5 Maintenance Area (2006 24-hour, NY-NJ-CT)	--	**8.07**	--	--	**0.24**	**0.02**	--	--	--	--	--	--	--
TOTAL, ALL AREAS	**19.65**	**186.75**	**245.64**	**6.31**	**6.08**	**2.41**	**1.68**	**7.42E-04**	**0.08**	**35,262**	**0.56**	**1.60**	**39,141**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-2. EW 1 Emission Summary

2023

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Texas state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Greene County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulster County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Orange County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Rockland County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bergen County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Rensselaer County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbia County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Dutchess County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Putnam County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Westchester County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bronx County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
New York County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Kings County, NY	0.10	0.69	0.25	0.03	0.03	1.58E-03	0.02	0.00E+00	5.43E-05	277.5	1.08E-02	6.29E-03	279.6
Queens County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Monmouth County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Nassau County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal/state waters inside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL	**0.10**	**0.69**	**0.25**	**0.03**	**0.03**	**1.58E-03**	**0.02**	**0.00E+00**	**5.43E-05**	**277**	**1.08E-02**	**6.29E-03**	**280**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-2. EW 1 Emission Summary

2024

Emissions by geographic area	**VOC**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**HAPs**	**Pb**	**H_2SO_4**	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
South Carolina state waters	3.59	85.03	13.94	1.73	1.63	2.21	0.32	2.04E-04	0.08	4,677.1	0.07	0.21	4,741.9
Texas state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Greene County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulster County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Orange County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Rockland County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bergen County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Rensselaer County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbia County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Dutchess County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Putnam County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Westchester County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bronx County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
New York County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Kings County, NY	10.97	279.76	54.36	5.38	5.07	6.28	1.06	6.16E-04	0.22	17,835.9	0.27	0.79	18,076.6
Queens County, NY	3.14	60.32	39.80	2.31	2.24	0.16	0.30	2.80E-04	5.49E-03	5,672.5	0.08	0.28	5,756.7
Monmouth County, NJ	7.08E-04	0.02	1.48E-03	2.51E-04	2.31E-04	5.39E-04	6.20E-05	2.89E-08	1.85E-05	0.9	1.34E-05	3.90E-05	0.9
Nassau County, NY	1.80E-03	0.02	5.54E-04	5.40E-04	5.40E-04	1.42E-03	4.67E-05	2.26E-08	4.90E-05	4.5	1.28E-04	1.49E-04	4.5
Federal waters outside OCS radius	**1.74**	**41.15**	**6.75**	**0.84**	**0.79**	**1.07**	**0.16**	**0.00**	**0.04**	**2,263**	**0.03**	**0.10**	**2,295**
Federal/state waters inside OCS radius	**7.38**	**161.14**	**74.77**	**4.32**	**4.15**	**1.90**	**0.68**	**0.00**	**0.07**	**12,976**	**0.18**	**0.62**	**13,165**
TOTAL	**26.82**	**627.44**	**189.61**	**14.58**	**13.88**	**11.61**	**2.52**	**1.72E-03**	**0.40**	**43,430**	**0.63**	**1.99**	**44,040**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-2. EW 1 Emission Summary

2025

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	3.44	22.52	17.45	1.40	1.34	0.46	0.31	1.68E-04	0.02	2,346.7	0.03	0.11	2,380.8
Texas state waters	0.14	0.22	0.37	1.34E-02	1.24E-02	0.03	1.17E-02	1.55E-06	9.12E-04	48.6	7.36E-04	2.17E-03	49.2
Albany County, NY	1.44E-02	0.26	0.18	9.45E-03	9.16E-03	2.20E-04	1.36E-03	1.15E-06	7.57E-06	23.9	3.51E-04	1.17E-03	24.3
Greene County, NY	0.03	0.57	0.38	0.02	0.02	4.80E-04	2.97E-03	2.50E-06	1.65E-05	52.2	7.65E-04	2.55E-03	53.0
Ulster County, NY	0.05	0.84	0.57	0.03	0.03	7.09E-04	4.38E-03	3.69E-06	2.44E-05	77.1	1.13E-03	3.77E-03	78.2
Orange County, NY	0.02	0.45	0.30	0.02	0.02	3.81E-04	2.35E-03	1.98E-06	1.31E-05	41.4	6.07E-04	2.03E-03	42.0
Rockland County, NY	0.03	0.54	0.37	0.02	0.02	4.57E-04	2.82E-03	2.38E-06	1.57E-05	49.7	7.28E-04	2.43E-03	50.4
Bergen County, NJ	0.02	0.32	0.22	1.15E-02	1.12E-02	2.69E-04	1.66E-03	1.40E-06	9.24E-06	29.2	4.28E-04	1.43E-03	29.7
Hudson County, NJ	1.04E-02	0.19	0.13	6.81E-03	6.61E-03	1.59E-04	9.80E-04	8.26E-07	5.46E-06	17.3	2.53E-04	8.44E-04	17.5
Rensselaer County, NY	1.42E-02	0.26	0.17	9.26E-03	8.99E-03	2.16E-04	1.33E-03	1.12E-06	7.42E-06	23.5	3.44E-04	1.15E-03	23.8
Columbia County, NY	0.04	0.65	0.44	0.02	0.02	5.50E-04	3.40E-03	2.86E-06	1.89E-05	59.8	8.76E-04	2.93E-03	60.7
Dutchess County, NY	0.06	1.00	0.68	0.04	0.04	8.44E-04	5.22E-03	4.39E-06	2.90E-05	91.8	1.34E-03	4.49E-03	93.2
Putnam County, NY	1.14E-02	0.21	0.14	7.45E-03	7.22E-03	1.73E-04	1.07E-03	9.03E-07	5.97E-06	18.9	2.76E-04	9.23E-04	19.2
Westchester County, NY	0.04	0.68	0.46	0.02	0.02	5.71E-04	3.53E-03	2.97E-06	1.97E-05	62.1	9.10E-04	3.04E-03	63.1
Bronx County, NY	3.05E-03	0.06	0.04	2.00E-03	1.94E-03	4.65E-05	2.88E-04	2.42E-07	1.60E-06	5.1	7.42E-05	2.48E-04	5.1
New York County, NY	0.02	0.32	0.22	1.17E-02	1.14E-02	2.73E-04	1.69E-03	1.42E-06	9.39E-06	29.7	4.35E-04	1.45E-03	30.1
Kings County, NY	6.63	171.46	22.78	3.81	3.60	4.09	0.72	4.25E-04	0.14	11,093.3	0.21	0.45	11,232.1
Queens County, NY	0.10	2.08	0.72	0.06	0.06	0.04	8.99E-03	6.95E-06	1.31E-03	155.2	2.43E-03	7.07E-03	157.4
Monmouth County, NJ	0.09	1.79	0.64	0.05	0.05	0.03	7.93E-03	6.18E-06	1.02E-03	124.5	1.75E-03	5.86E-03	126.3
Nassau County, NY	9.56E-03	0.12	2.93E-03	2.86E-03	2.86E-03	7.55E-03	2.48E-04	1.20E-07	2.60E-04	23.8	6.80E-04	7.87E-04	24.0
Federal waters outside OCS radius	**11.91**	**26.24**	**34.86**	**1.64**	**1.54**	**2.15**	**0.99**	**1.92E-04**	**0.07**	**4,618**	**0.07**	**0.21**	**4,682**
Federal/state waters inside OCS radius	**100.05**	**1,268.55**	**472.28**	**33.97**	**32.15**	**31.74**	**8.75**	**4.02E-03**	**1.09**	**94,971**	**1.31**	**4.39**	**96,312**
TOTAL	**122.72**	**1,499.30**	**553.38**	**41.17**	**38.98**	**38.54**	**10.83**	**4.84E-03**	**1.33**	**113,963**	**1.64**	**5.21**	**115,555**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-2. EW 1 Emission Summary

2026

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Texas state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany County, NY	0.04	0.78	0.53	0.03	0.03	6.60E-04	4.08E-03	3.44E-06	2.27E-05	71.8	1.05E-03	3.51E-03	72.9
Greene County, NY	0.09	1.71	1.15	0.06	0.06	1.44E-03	8.90E-03	7.50E-06	4.96E-05	156.7	2.30E-03	7.66E-03	159.0
Ulster County, NY	0.14	2.52	1.70	0.09	0.09	2.13E-03	1.31E-02	1.11E-05	7.31E-05	231.3	3.39E-03	1.13E-02	234.7
Orange County, NY	0.07	1.35	0.91	0.05	0.05	1.14E-03	7.06E-03	5.95E-06	3.93E-05	124.3	1.82E-03	6.08E-03	126.1
Rockland County, NY	0.09	1.62	1.10	0.06	0.06	1.37E-03	8.47E-03	7.14E-06	4.72E-05	149.1	2.18E-03	7.29E-03	151.3
Bergen County, NJ	0.05	0.95	0.65	0.03	0.03	8.06E-04	4.98E-03	4.20E-06	2.77E-05	87.7	1.28E-03	4.29E-03	89.0
Hudson County, NJ	0.03	0.56	0.38	0.02	0.02	4.76E-04	2.94E-03	2.48E-06	1.64E-05	51.8	7.58E-04	2.53E-03	52.5
Rensselaer County, NY	0.04	0.77	0.52	0.03	0.03	6.47E-04	4.00E-03	3.37E-06	2.23E-05	70.4	1.03E-03	3.44E-03	71.5
Columbia County, NY	0.11	1.95	1.32	0.07	0.07	1.65E-03	1.02E-02	8.59E-06	5.68E-05	179.5	2.63E-03	8.78E-03	182.2
Dutchess County, NY	0.17	3.00	2.03	0.11	0.11	2.53E-03	0.02	1.32E-05	8.71E-05	275.4	4.03E-03	1.35E-02	279.5
Putnam County, NY	0.03	0.62	0.42	0.02	0.02	5.20E-04	3.22E-03	2.71E-06	1.79E-05	56.6	8.29E-04	2.77E-03	57.5
Westchester County, NY	0.11	2.03	1.37	0.07	0.07	1.71E-03	1.06E-02	8.92E-06	5.90E-05	186.4	2.73E-03	9.11E-03	189.2
Bronx County, NY	9.16E-03	0.17	0.11	5.99E-03	5.81E-03	1.40E-04	8.63E-04	7.27E-07	4.80E-06	15.2	2.22E-04	7.43E-04	15.4
New York County, NY	0.05	0.97	0.66	0.04	0.03	8.19E-04	5.06E-03	4.26E-06	2.82E-05	89.1	1.30E-03	4.35E-03	90.4
Kings County, NY	0.96	11.74	10.10	0.50	0.48	0.02	0.13	4.31E-05	5.84E-04	2,032.5	0.09	0.06	2,606.3
Queens County, NY	0.15	2.47	1.97	0.11	0.11	3.65E-03	1.44E-02	1.37E-05	1.26E-04	271.9	3.67E-03	1.32E-02	275.9
Monmouth County, NJ	0.13	2.21	1.78	0.10	0.10	2.22E-03	1.30E-02	1.23E-05	7.63E-05	241.3	3.21E-03	1.18E-02	244.9
Nassau County, NY	8.51E-03	0.11	2.61E-03	2.55E-03	2.55E-03	6.73E-03	2.20E-04	1.07E-07	2.31E-04	21.2	6.06E-04	7.01E-04	21.4
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal/state waters inside OCS radius	**46.21**	**403.52**	**369.43**	**16.22**	**15.63**	**4.90**	**4.04**	**1.95E-03**	**0.17**	**50,255**	**0.68**	**2.38**	**51,302**
TOTAL	**48.52**	**439.05**	**396.12**	**17.63**	**17.00**	**4.95**	**4.30**	**2.10E-03**	**0.17**	**54,567**	**0.81**	**2.55**	**56,222**

2027 Onward (O&M)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
Kings County, NY	0.24	3.03	3.11	0.10	0.10	7.78E-03	0.02	3.49E-06	2.68E-04	632.6	0.03	0.02	1,191.2
Queens County, NY	0.03	0.29	0.59	7.80E-03	7.55E-03	1.57E-03	2.28E-03	9.43E-07	5.41E-05	81.44	9.99E-04	3.98E-03	82.65
Monmouth County, NJ	0.02	0.26	0.53	7.02E-03	6.79E-03	1.41E-03	2.05E-03	8.49E-07	4.87E-05	73.30	8.99E-04	3.58E-03	74.39
Nassau County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal/state waters inside OCS radius	**7.07**	**67.43**	**82.72**	**2.21**	**2.12**	**1.01**	**0.60**	**2.65E-04**	**0.03**	**11,978**	**0.18**	**0.54**	**12,464**
TOTAL	**7.36**	**71.00**	**86.96**	**2.32**	**2.23**	**1.02**	**0.62**	**2.70E-04**	**0.04**	**12,766**	**0.22**	**0.56**	**13,813**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-3. EW 2 Emission Summary

2024

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Texas state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Greene County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulster County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Orange County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Rockland County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bergen County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Rensselaer County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbia County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Dutchess County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Putnam County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Westchester County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bronx County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
New York County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Kings County, NY	4.15E-04	0.02	5.33E-03	8.36E-04	8.11E-04	1.40E-05	5.07E-05	1.01E-07	4.82E-07	1.52	7.92E-06	7.45E-05	1.55
Queens County, NY	1.60E-04	9.00E-03	2.05E-03	3.21E-04	3.12E-04	5.39E-06	1.95E-05	3.90E-08	1.85E-07	0.59	3.05E-06	2.87E-05	0.59
Monmouth County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Nassau County, NY	1.46	40.39	9.32	1.85	1.79	0.03	0.24	2.00E-04	1.03E-03	3,857.7	0.07	0.15	3,904.4
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal/state waters inside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL	**1.46**	**40.43**	**9.33**	**1.85**	**1.79**	**0.03**	**0.24**	**2.01E-04**	**1.03E-03**	**3,860**	**0.07**	**0.15**	**3,907**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-3. EW 2 Emission Summary

2025

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	2.66	9.19	9.44	0.56	0.53	0.44	0.23	6.65E-05	0.02	1,258.0	0.02	0.06	1,275.7
Texas state waters	0.07	0.11	0.18	6.70E-03	6.19E-03	1.33E-02	5.84E-03	7.74E-07	4.56E-04	24.3	3.68E-04	1.08E-03	24.6
Albany County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Greene County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulster County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Orange County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Rockland County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bergen County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson County, NJ	0	0	0	0	0	0	0	0	0	0	0	0	0
Rensselaer County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbia County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Dutchess County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Putnam County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Westchester County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Bronx County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
New York County, NY	0	0	0	0	0	0	0	0	0	0	0	0	0
Kings County, NY	0.16	1.71	1.13	0.05	0.05	0.02	0.03	2.99E-06	7.90E-04	334.3	0.02	8.99E-03	337.4
Queens County, NY	0.02	0.44	0.11	1.02E-02	9.71E-03	9.53E-03	1.62E-03	1.17E-06	3.28E-04	31.4	4.71E-04	1.40E-03	31.8
Monmouth County, NJ	1.48E-02	0.35	0.09	7.54E-03	7.15E-03	7.32E-03	1.34E-03	8.93E-07	2.52E-04	22.3	3.01E-04	1.03E-03	22.6
Nassau County, NY	8.36	221.33	74.41	10.51	10.19	0.26	1.07	1.22E-03	8.95E-03	18,292.1	0.25	0.82	18,541.3
Federal waters outside OCS radius	**5.86**	**11.44**	**16.47**	**0.70**	**0.66**	**1.07**	**0.49**	**8.22E-05**	**0.04**	**2,179**	**0.03**	**0.10**	**2,209**
Federal/state waters inside OCS radius	**45.70**	**553.31**	**216.05**	**17.07**	**16.26**	**12.85**	**4.03**	**2.03E-03**	**0.44**	**42,051**	**0.55**	**1.95**	**42,647**
TOTAL	**62.85**	**797.87**	**317.89**	**28.92**	**27.71**	**14.68**	**5.85**	**0.00**	**0.51**	**64,193**	**0.87**	**2.94**	**65,090**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-3. EW 2 Emission Summary

2026

Emissions by geographic area	**VOC**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**HAPs**	**Pb**	**H_2SO_4**	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
South Carolina state waters	1.45	26.16	15.82	1.58	1.53	0.02	0.15	1.92E-04	6.80E-04	2,150.4	0.03	0.11	2,182.5
Texas state waters	0.07	0.11	0.18	6.70E-03	6.19E-03	1.33E-02	5.84E-03	7.74E-07	4.56E-04	24.3	3.68E-04	1.08E-03	24.6
Albany County, NY	0.02	0.33	0.22	1.19E-02	1.16E-02	2.78E-04	1.72E-03	1.45E-06	9.56E-06	30.2	4.43E-04	1.48E-03	30.7
Greene County, NY	0.04	0.72	0.49	0.03	0.03	6.07E-04	3.75E-03	3.16E-06	2.09E-05	66.0	9.67E-04	3.23E-03	67.0
Ulster County, NY	0.06	1.06	0.72	0.04	0.04	8.95E-04	5.53E-03	4.66E-06	3.08E-05	97.4	1.43E-03	4.76E-03	98.8
Orange County, NY	0.03	0.57	0.38	0.02	0.02	4.81E-04	2.97E-03	2.50E-06	1.65E-05	52.3	7.66E-04	2.56E-03	53.1
Rockland County, NY	0.04	0.68	0.46	0.02	0.02	5.77E-04	3.57E-03	3.00E-06	1.99E-05	62.8	9.20E-04	3.07E-03	63.7
Bergen County, NJ	0.02	0.40	0.27	1.46E-02	1.41E-02	3.39E-04	2.10E-03	1.77E-06	1.17E-05	36.9	5.41E-04	1.81E-03	37.5
Hudson County, NJ	1.31E-02	0.24	0.16	8.60E-03	8.35E-03	2.00E-04	1.24E-03	1.04E-06	6.89E-06	21.8	3.19E-04	1.07E-03	22.1
Rensselaer County, NY	0.02	0.32	0.22	1.17E-02	1.14E-02	2.73E-04	1.68E-03	1.42E-06	9.38E-06	29.6	4.34E-04	1.45E-03	30.1
Columbia County, NY	0.05	0.82	0.56	0.03	0.03	6.95E-04	4.29E-03	3.62E-06	2.39E-05	75.6	1.11E-03	3.70E-03	76.7
Dutchess County, NY	0.07	1.26	0.85	0.05	0.04	1.07E-03	6.59E-03	5.55E-06	3.67E-05	116.0	1.70E-03	5.67E-03	117.7
Putnam County, NY	1.44E-02	0.26	0.18	9.41E-03	9.13E-03	2.19E-04	1.35E-03	1.14E-06	7.54E-06	23.8	3.49E-04	1.17E-03	24.2
Westchester County, NY	0.05	0.85	0.58	0.03	0.03	7.21E-04	4.46E-03	3.76E-06	2.48E-05	78.5	1.15E-03	3.84E-03	79.7
Bronx County, NY	3.86E-03	0.07	0.05	2.52E-03	2.45E-03	5.88E-05	3.63E-04	3.06E-07	2.02E-06	6.4	9.37E-05	3.13E-04	6.5
New York County, NY	0.02	0.41	0.28	1.48E-02	1.44E-02	3.45E-04	2.13E-03	1.79E-06	1.19E-05	37.5	5.49E-04	1.83E-03	38.1
Kings County, NY	0.62	7.18	4.87	0.26	0.26	0.07	0.10	2.14E-05	2.35E-03	1,186.8	0.05	0.04	1,198.7
Queens County, NY	0.09	1.83	0.74	0.06	0.06	0.03	8.46E-03	7.23E-06	8.65E-04	133.6	1.92E-03	6.30E-03	135.5
Monmouth County, NJ	0.08	1.63	0.66	0.05	0.05	0.02	7.58E-03	6.49E-06	7.46E-04	117.2	1.64E-03	5.57E-03	118.9
Nassau County, NY	7.55E-03	0.10	2.32E-03	2.26E-03	2.26E-03	5.96E-03	1.95E-04	9.45E-08	2.05E-04	18.8	5.37E-04	6.22E-04	19.0
Federal waters outside OCS radius	5.28	19.65	19.56	1.20	1.14	0.87	0.45	1.43E-04	0.03	2,610.8	0.04	0.12	2,647.9
Federal/state waters inside OCS radius	**80.00**	**1,403.27**	**463.86**	**40.05**	**38.20**	**28.41**	**7.26**	**4.77E-03**	**0.98**	**96,718**	**1.33**	**4.51**	**98,094**
TOTAL	**88.04**	**1,467.92**	**511.11**	**43.51**	**41.53**	**29.44**	**8.03**	**5.18E-03**	**1.01**	**103,695**	**1.47**	**4.82**	**105,167**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-3. EW 2 Emission Summary

2027

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
South Carolina state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Texas state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany County, NY	0.07	1.32	0.89	0.05	0.05	1.11E-03	6.87E-03	5.79E-06	3.82E-05	120.9	1.77E-03	5.91E-03	122.7
Greene County, NY	0.16	2.87	1.94	0.10	0.10	2.43E-03	1.50E-02	1.26E-05	8.35E-05	263.9	3.87E-03	1.29E-02	267.9
Ulster County, NY	0.23	4.24	2.87	0.15	0.15	3.58E-03	0.02	1.86E-05	1.23E-04	389.5	5.71E-03	0.02	395.3
Orange County, NY	0.13	2.28	1.54	0.08	0.08	1.92E-03	1.19E-02	1.00E-05	6.62E-05	209.3	3.07E-03	1.02E-02	212.4
Rockland County, NY	0.15	2.73	1.85	0.10	0.10	2.31E-03	1.43E-02	1.20E-05	7.94E-05	251.1	3.68E-03	1.23E-02	254.9
Bergen County, NJ	0.09	1.61	1.09	0.06	0.06	1.36E-03	8.39E-03	7.07E-06	4.67E-05	147.7	2.16E-03	7.22E-03	149.9
Hudson County, NJ	0.05	0.95	0.64	0.03	0.03	8.02E-04	4.95E-03	4.17E-06	2.76E-05	87.2	1.28E-03	4.26E-03	88.5
Rensselaer County, NY	0.07	1.29	0.87	0.05	0.05	1.09E-03	6.74E-03	5.68E-06	3.75E-05	118.6	1.74E-03	5.80E-03	120.4
Columbia County, NY	0.18	3.29	2.22	0.12	0.12	2.78E-03	0.02	1.45E-05	9.56E-05	302.3	4.43E-03	1.48E-02	306.8
Dutchess County, NY	0.28	5.05	3.41	0.18	0.18	4.26E-03	0.03	2.22E-05	1.47E-04	463.9	6.80E-03	0.02	470.8
Putnam County, NY	0.06	1.04	0.70	0.04	0.04	8.76E-04	5.42E-03	4.56E-06	3.02E-05	95.3	1.40E-03	4.66E-03	96.8
Westchester County, NY	0.19	3.42	2.31	0.12	0.12	2.89E-03	0.02	1.50E-05	9.93E-05	313.9	4.60E-03	0.02	318.6
Bronx County, NY	0.02	0.28	0.19	1.01E-02	9.79E-03	2.35E-04	1.45E-03	1.22E-06	8.09E-06	25.6	3.75E-04	1.25E-03	26.0
New York County, NY	0.09	1.63	1.10	0.06	0.06	1.38E-03	8.52E-03	7.18E-06	4.74E-05	150.0	2.20E-03	7.33E-03	152.2
Kings County, NY	1.31	15.46	13.98	0.69	0.67	0.02	0.19	6.85E-05	7.31E-04	2,630.2	0.10	0.09	2,660.6
Queens County, NY	0.25	3.99	3.30	0.18	0.18	6.27E-03	0.02	2.23E-05	2.16E-04	454.6	6.15E-03	0.02	461.3
Monmouth County, NJ	0.22	3.56	2.97	0.17	0.16	3.70E-03	0.02	2.00E-05	1.27E-04	403.0	5.36E-03	0.02	409.0
Nassau County, NY	0.13	2.21	1.16	0.07	0.07	1.44E-02	2.64E-03	1.28E-06	4.95E-04	267.9	1.04E-02	3.13E-03	1,690.7
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal/state waters inside OCS radius	**67.35**	**572.85**	**542.49**	**23.34**	**22.48**	**7.26**	**5.89**	**2.81E-03**	**0.25**	**73,674**	**0.99**	**3.51**	**75,836**
TOTAL	**71.03**	**630.05**	**585.52**	**25.61**	**24.69**	**7.33**	**6.29**	**3.06E-03**	**0.25**	**80,369**	**1.15**	**3.79**	**84,041**

2028 Onward (O&M)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	Pb	H_2SO_4	CO_2	CH_4	N_2O	CO_2e
Kings County, NY	0.19	1.55	3.35	0.05	0.05	0.01	0.02	0.00	0.00	593.29	0.02	0.02	600.69
Queens County, NY	0.05	0.49	1.15	0.01	0.01	0.00	0.00	0.00	0.00	157.12	0.00	0.01	159.45
Monmouth County, NJ	0.04	0.44	1.03	0.01	0.01	0.00	0.00	0.00	0.00	141.41	0.00	0.01	143.51
Nassau County, NY	0.11	2.01	1.16	0.07	0.06	0.00	0.00	0.00	0.00	229.50	0.01	0.00	1,651.9
Federal waters outside OCS radius	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Federal/state waters inside OCS radius	**11.90**	**111.25**	**151.99**	**3.85**	**3.71**	**1.38**	**1.02**	**0.00**	**0.05**	**21,375**	**0.30**	**1.00**	**22,772**
TOTAL	**12.29**	**115.75**	**158.68**	**3.99**	**3.84**	**1.39**	**1.06**	**0.00**	**0.05**	**22496.59**	**0.34**	**1.04**	**25327.83**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-4. Decommissioning Emission Summary

Decommissioning of EW 1 and EW 2

Emissions by geographic area	**VOC**	**NO_X**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**HAPs**	**Pb**	**H_2SO_4**	**CO_2**	**CH_4**	**N_2O**	**CO_2e**
South Carolina state waters	0	0	0	0	0	0	0	0	0	0	0	0	0
Texas state waters	0.06	0.09	0.15	5.36E-03	4.95E-03	1.06E-02	4.67E-03	6.19E-07	3.65E-04	19.4	2.95E-04	8.67E-04	19.7
Albany County, NY	0.03	0.54	0.36	0.02	0.02	4.54E-04	2.80E-03	2.36E-06	1.56E-05	49.4	7.23E-04	2.41E-03	50.1
Greene County, NY	0.07	1.17	0.79	0.04	0.04	9.91E-04	6.12E-03	5.16E-06	3.41E-05	107.8	1.58E-03	5.27E-03	109.4
Ulster County, NY	0.10	1.73	1.17	0.06	0.06	1.46E-03	9.03E-03	7.61E-06	5.03E-05	159.0	2.33E-03	7.78E-03	161.4
Orange County, NY	0.05	0.93	0.63	0.03	0.03	7.86E-04	4.85E-03	4.09E-06	2.70E-05	85.5	1.25E-03	4.18E-03	86.7
Rockland County, NY	0.06	1.12	0.75	0.04	0.04	9.43E-04	5.82E-03	4.91E-06	3.24E-05	102.5	1.50E-03	5.01E-03	104.1
Bergen County, NJ	0.04	0.66	0.44	0.02	0.02	5.54E-04	3.42E-03	2.89E-06	1.91E-05	60.3	8.83E-04	2.95E-03	61.2
Hudson County, NJ	0.02	0.39	0.26	1.41E-02	1.36E-02	3.27E-04	2.02E-03	1.70E-06	1.13E-05	35.6	5.22E-04	1.74E-03	36.1
Rensselaer County, NY	0.03	0.53	0.36	0.02	0.02	4.45E-04	2.75E-03	2.32E-06	1.53E-05	48.4	7.09E-04	2.37E-03	49.1
Columbia County, NY	0.07	1.34	0.91	0.05	0.05	1.13E-03	7.01E-03	5.91E-06	3.90E-05	123.4	1.81E-03	6.04E-03	125.3
Dutchess County, NY	0.11	2.06	1.39	0.07	0.07	1.74E-03	1.08E-02	9.07E-06	5.99E-05	189.4	2.77E-03	9.26E-03	192.3
Putnam County, NY	0.02	0.42	0.29	0.02	1.49E-02	3.58E-04	2.21E-03	1.86E-06	1.23E-05	38.9	5.70E-04	1.90E-03	39.5
Westchester County, NY	0.08	1.40	0.94	0.05	0.05	1.18E-03	7.28E-03	6.13E-06	4.05E-05	128.2	1.88E-03	6.27E-03	130.1
Bronx County, NY	6.30E-03	0.11	0.08	4.12E-03	4.00E-03	9.60E-05	5.93E-04	5.00E-07	3.30E-06	10.4	1.53E-04	5.11E-04	10.6
New York County, NY	0.04	0.67	0.45	0.02	0.02	5.63E-04	3.48E-03	2.93E-06	1.94E-05	61.2	8.97E-04	2.99E-03	62.2
Kings County, NY	0.65	10.67	5.84	0.45	0.44	0.04	0.08	5.09E-05	1.24E-03	1,101.0	0.03	0.04	1,115.0
Queens County, NY	1.14	19.78	14.54	0.78	0.75	0.03	0.11	9.42E-05	1.06E-03	1,984.4	0.03	0.10	2,013.9
Monmouth County, NJ	0.13	1.58	0.97	0.09	0.08	9.71E-03	1.23E-02	1.06E-05	3.34E-04	132.1	1.93E-03	6.39E-03	134.0
Nassau County, NY	0.94	14.47	9.81	0.77	0.74	0.02	0.12	8.71E-05	7.56E-04	1,597.4	0.04	0.07	1,618.1
Federal waters outside OCS radius	**18.30**	**27.98**	**47.62**	**1.73**	**1.60**	**3.43**	**1.51**	**2.00E-04**	**0.12**	**6,281.2**	**0.10**	**0.28**	**6,367.1**
Federal waters inside OCS radius	**53.63**	**500.50**	**234.44**	**18.02**	**17.17**	**13.46**	**4.69**	**2.14E-03**	**0.46**	**40,774.2**	**0.60**	**1.89**	**41,352.1**
Ozone NAA (NY-NJ-CT)	**3.10**	**50.84**	--	--	--	--	--	--	--	--	--	--	--
PM10 NAA (New York County)	--	--	--	**0.02**	--	--	--	--	--	--	--	--	--
CO Maintenance Area (NY-NJ-CT)	--	--	**32.37**	--	--	--	--	--	--	--	--	--	--
PM2.5 Maintenance Area (1997 Annual, NY-NJ-CT)	--	**51.77**	--	--	**2.20**	**0.10**	--	--	--	--	--	--	--
PM2.5 Maintenance Area (2006 24-hour, NY-NJ-CT)	--	**51.77**	--	--	**2.20**	**0.10**	--	--	--	--	--	--	--
TOTAL, ALL AREAS	**75.57**	**588.13**	**322.20**	**22.31**	**21.25**	**17.01**	**6.59**	**2.65E-03**	**0.59**	**53,090**	**0.82**	**2.44**	**53,838**

Note: Decommissioning emissions are estimated to be 20% of offshore construction emissions, except that seabed preparation and wind farm commissioning tasks are assumed not to be required.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-5. EW 1 Foundation Construction Emissions (Monopile Design)

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Helicopter - Twin-Engine Heavy		N/A							
Main Engines	2			164	1,400	Jet fuel	N/A	N/A	N/A
Main Installation Vessel		1	661 x 290 x 162 (43)						
Main Engines	6			1.31	6,568	Diesel	86,000	52,000	3.18
Main Engines	4			1.31	6,032	Diesel			
Main Engines	2			1.31	7,373	Diesel			
Motion Compensated Gripper Frame Generator	1	N/A	N/A	4.02	2,188	Diesel	0	8,343	3.18
Heavy Transport Vessel 1		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Heavy Transport Vessel 2		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Heavy Transport Vessel 3		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Fall Pipe Vessel - Seabed filter layer		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
Fall Pipe Vessel - Scour protection		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
Anchor Handling Tug		1	236 x 59 x 27 (24)						
Main Engines	4			1.31	4,021	Diesel	42,000	10,000	3.18
Bubble Curtain Vessel		N/A	150 x 36 x 10						
Main Engines	2			2.07	750	Diesel	4,000	4,000	3.18
Aux. Engine	1			2.04	133	Diesel			
Bow Thruster Engine	1			2.04	325	Diesel			
Aux. Engine	1			2.04	133	Diesel			
Crew Transfer Vessel 1 (Primary)		N/A	65 x 17 x 5						
Main Engines	2			4.02	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			3.03	27	Diesel			
Protected Species Observer (PSO) Vessel		N/A	65 x 17 x 5						
Main Engines	2			2.06	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			2.03	27	Diesel			
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-5. EW 1 Foundation Construction Emissions (Monopile Design)

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Helicopter - Twin-Engine Heavy										
Main Engines	26	0.5	0	0	0	0	100%	0%	4,092	0
Main Installation Vessel										
Main Engines	1	6	0	90	24	2,160	30%	18%	6,761	1,471,698
Main Engines	1	6	0	90	24	2,160	30%	18%		
Main Engines	1	6	0	90	24	2,160	30%	18%		
Motion Compensated Gripper Frame Generator										
	0	0	0	19	24	456	0%	100%	0	49,848
Heavy Transport Vessel 1										
Main Engines	4	6	0	24	24	576	44%	8%	17,296	75,472
Main Engines	4	6	0	24	24	576	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Transport Vessel 2										
Main Engines	4	6	0	24	24	576	44%	8%	17,296	75,472
Main Engines	4	6	0	24	24	576	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Transport Vessel 3										
Main Engines	4	6	0	24	24	576	44%	8%	17,296	75,472
Main Engines	4	6	0	24	24	576	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Fall Pipe Vessel - Seabed filter layer										
Main Engines	12	6	0	90	24	2,160	69%	14%	47,170	283,019
Aux. Engine	12	6	0	90	24	2,160	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Fall Pipe Vessel - Scour protection										
Main Engines	12	6	0	90	24	2,160	69%	14%	47,170	283,019
Aux. Engine	12	6	0	90	24	2,160	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Anchor Handling Tug										
Main Engines	13	9	0	90	24	2,160	71%	17%	64,387	283,019
Bubble Curtain Vessel										
Main Engines	3	9	0	90	24	2,160	64%	50%	1,415	113,208
Aux. Engine	3	9	0	90	24	2,160	64%	50%		
Bow Thruster Engine	0	0	0	90	24	2,160	0%	50%		
Aux. Engine	0	0	0	90	24	2,160	0%	50%		
Crew Transfer Vessel 1 (Primary)										
Main Engines	13	9	0	90	24	2,160	64%	51%	7,665	113,208
Main Engines	13	9	0	90	24	2,160	64%	51%		
Protected Species Observer (PSO) Vessel										
Main Engines	13	9	0	90	24	2,160	64%	51%	7,665	113,208
Main Engines	13	9	0	90	24	2,160	64%	51%		
TOTALS									**238,211**	**2,936,641**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-5. EW 1 Foundation Construction Emissions (Monopile Design)

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Main Installation Vessel													
Main Engines	6.67	167.22	13.94	2.37	2.18	5.08	0.58	2.72E-04	1.75E-01	8,326.08	0.13	0.37	8,438.73
Main Engines	4.08	102.38	8.53	1.45	1.33	3.11	0.36	1.67E-04	1.07E-01	5,097.60	0.08	0.22	5,166.57
Main Engines	2.50	62.57	5.21	0.89	0.81	1.90	0.22	1.02E-04	6.54E-02	3,115.20	0.05	0.14	3,157.35
Motion Compensated Gripper Frame Generator	0.12	1.10	3.06	0.02	0.02	3.82E-03	1.04E-02	2.60E-06	1.32E-04	415.82	5.02E-03	2.03E-02	422.00
Heavy Transport Vessel 1													
Main Engines	2.43	2.99	5.76	0.22	0.20	0.46	0.20	2.47E-05	0.02	757.24	1.15E-02	0.03	767.48
Main Engines	0.04	0.78	0.67	0.02	0.02	8.32E-04	3.89E-03	2.26E-06	2.86E-05	90.46	1.33E-03	4.42E-03	91.81
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 2													
Main Engines	2.43	2.99	5.76	0.22	0.20	0.46	0.20	2.47E-05	0.02	757.24	1.15E-02	0.03	767.48
Main Engines	0.04	0.78	0.67	0.02	0.02	8.32E-04	3.89E-03	2.26E-06	2.86E-05	90.46	1.33E-03	4.42E-03	91.81
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 3													
Main Engines	2.43	2.99	5.76	0.22	0.20	0.46	0.20	2.47E-05	0.02	757.24	1.15E-02	0.03	767.48
Main Engines	0.04	0.78	0.67	0.02	0.02	8.32E-04	3.89E-03	2.26E-06	2.86E-05	90.46	1.33E-03	4.42E-03	91.81
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Seabed filter layer													
Main Engines	2.33	58.48	4.87	0.83	0.76	1.78	0.20	9.51E-05	6.11E-02	2,911.64	0.04	0.13	2,951.04
Aux. Engine	0.06	4.15	0.98	0.12	0.12	2.46E-03	0.01	1.48E-05	8.46E-05	267.57	0.00	1.31E-02	271.50
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	2.33	58.48	4.87	0.83	0.76	1.78	0.20	9.51E-05	0.06	2,911.64	0.04	0.13	2,951.04
Aux. Engine	0.06	4.15	0.98	0.12	0.12	2.46E-03	0.01	1.48E-05	8.46E-05	267.57	0.00	1.31E-02	271.50
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Anchor Handling Tug													
Main Engines	2.55	63.88	5.32	0.90	0.83	1.94	0.22	1.04E-04	0.07	3,180.56	0.05	0.14	3,223.59
Bubble Curtain Vessel													
Main Engines	0.51	9.14	6.68	0.27	0.26	8.35E-03	0.05	3.24E-05	2.87E-04	908.09	0.01	0.04	921.59
Aux. Engine	0.05	0.84	0.59	0.05	0.05	7.40E-04	4.75E-03	5.75E-06	2.55E-05	80.52	9.72E-04	3.94E-03	81.71
Bow Thruster Engine	0.11	2.06	1.45	0.12	0.11	1.81E-03	1.16E-02	1.40E-05	6.22E-05	196.75	0.00	9.62E-03	199.68
Aux. Engine	0.05	0.84	0.59	0.05	0.05	7.40E-04	4.75E-03	5.75E-06	2.55E-05	80.52	9.72E-04	3.94E-03	81.71
Crew Transfer Vessel 1 (Primary)													
Main Engines	0.36	3.27	9.07	0.07	0.07	1.13E-02	0.03	8.80E-06	3.90E-04	1,232.82	0.01	0.06	1,251.16
Main Engines	1.20E-02	0.22	0.24	0.01	1.42E-02	3.04E-04	1.27E-03	1.77E-06	1.05E-05	33.05	3.99E-04	1.62E-03	33.54
Protected Species Observer (PSO) Vessel													
Main Engines	0.69	12.41	9.07	0.36	0.35	1.13E-02	0.06	4.40E-05	3.90E-04	1,232.82	0.01	0.06	1,251.16
Main Engines	1.95E-02	0.35	0.27	0.03	2.83E-02	3.04E-04	2.18E-03	3.54E-06	1.05E-05	33.05	3.99E-04	1.62E-03	33.54
TOTALS	**29.90**	**562.88**	**95.01**	**9.18**	**8.51**	**17.01**	**2.59**	**1.06E-03**	**0.59**	**32,834.39**	**0.48**	**1.47**	**33,285.29**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-5. EW 1 Foundation Construction Emissions (Monopile Design)

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0.02	0.23	5.33E-03	5.20E-03	5.20E-03	1.37E-02	4.50E-04	2.17E-07	4.72E-04	43.16	1.24E-03	1.43E-03	43.62
Main Installation Vessel													
Main Engines	3.06E-02	0.77	0.06	0.01	0.01	0.02	2.68E-03	1.25E-06	8.03E-04	38.25	5.82E-04	1.69E-03	38.77
Main Engines	1.88E-02	0.47	0.04	0.01	0.01	1.43E-02	1.64E-03	7.65E-07	4.91E-04	23.42	3.56E-04	1.03E-03	23.74
Main Engines	1.15E-02	0.29	0.02	4.07E-03	3.74E-03	8.73E-03	1.00E-03	4.68E-07	3.00E-04	14.31	2.18E-04	6.31E-04	14.50
Motion Compensated Gripper Frame Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 1													
Main Engines	0.56	0.69	1.32	0.05	0.05	0.11	0.05	5.67E-06	3.64E-03	173.53	2.64E-03	7.66E-03	175.88
Main Engines	9.96E-03	0.18	0.15	4.27E-03	4.14E-03	1.91E-04	8.92E-04	5.18E-07	6.56E-06	20.73	3.05E-04	1.01E-03	21.04
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 2													
Main Engines	0.56	0.69	1.32	0.05	0.05	0.11	0.05	5.67E-06	3.64E-03	173.53	2.64E-03	7.66E-03	175.88
Main Engines	9.96E-03	0.18	0.15	4.27E-03	4.14E-03	1.91E-04	8.92E-04	5.18E-07	6.56E-06	20.73	3.05E-04	1.01E-03	21.04
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 3													
Main Engines	0.56	0.69	1.32	0.05	0.05	0.11	0.05	5.67E-06	3.64E-03	173.53	2.64E-03	7.66E-03	175.88
Main Engines	9.96E-03	0.18	0.15	4.27E-03	4.14E-03	1.91E-04	8.92E-04	5.18E-07	6.56E-06	20.73	3.05E-04	1.01E-03	21.04
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Seabed filter layer													
Main Engines	0.39	9.75	0.81	0.14	0.13	0.30	0.03	1.59E-05	1.02E-02	485.27	7.38E-03	0.02	491.84
Aux. Engine	0.01	0.69	0.16	0.02	0.02	4.10E-04	1.17E-03	2.46E-06	1.41E-05	44.60	1.77E-04	2.18E-03	45.25
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	0.39	9.75	0.81	0.14	0.13	0.30	0.03	1.59E-05	1.02E-02	485.27	7.38E-03	0.02	491.84
Aux. Engine	0.01	0.69	0.16	0.02	0.02	4.10E-04	1.17E-03	2.46E-06	1.41E-05	44.60	1.77E-04	2.18E-03	45.25
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Anchor Handling Tug													
Main Engines	0.58	14.53	1.21	0.21	0.19	0.44	0.05	2.36E-05	0.02	723.58	1.10E-02	0.03	733.37
Bubble Curtain Vessel													
Main Engines	8.11E-03	0.15	0.11	4.28E-03	4.15E-03	1.34E-04	7.42E-04	5.19E-07	4.60E-06	14.53	1.75E-04	7.11E-04	14.75
Aux. Engine	7.49E-04	1.35E-02	9.48E-03	7.59E-04	7.36E-04	1.18E-05	7.61E-05	9.20E-08	4.08E-07	1.29	1.56E-05	6.30E-05	1.31
Bow Thruster Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Crew Transfer Vessel 1 (Primary)													
Main Engines	0.02	0.22	0.61	0.00	0.00	7.67E-04	2.08E-03	5.96E-07	2.64E-05	83.47	1.01E-03	4.08E-03	84.71
Main Engines	8.15E-04	0.01	0.02	9.88E-04	9.58E-04	2.06E-05	8.61E-05	1.20E-07	7.08E-07	2.24	2.70E-05	1.09E-04	2.27
Protected Species Observer (PSO) Vessel													
Main Engines	0.05	0.84	0.61	0.02	0.02	7.67E-04	4.26E-03	2.98E-06	2.64E-05	83.47	1.01E-03	4.08E-03	84.71
Main Engines	1.32E-03	0.02	0.02	1.98E-03	1.92E-03	2.06E-05	1.47E-04	2.40E-07	7.08E-07	2.24	2.70E-05	1.09E-04	2.27
TOTALS	**3.23**	**41.02**	**9.09**	**0.75**	**0.69**	**1.41**	**0.27**	**8.61E-05**	**0.05**	**2,672.49**	**0.04**	**0.12**	**2,708.96**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)\ *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-5. EW 1 Foundation Construction Emissions (Monopile Design)

Notes:

1. Emission calculations provided in this assessment are based on development of up to 57 wind turbine locations for EW 1.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
   Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
3. The number of transits for each vessel are based on the following assumptions:
   4 round trips to/from overseas port for each heavy transport vessel.
   1 round trip to/from overseas port for the heavy lift installation vessel.
   12 round trips to/from overseas port for each fall pipe vessel (based on assumed capacity to treat 5 foundations per cargo).
   Weekly round trips to/from port for the anchor handling tug and crew transfer vessel. Monthly round trips to/from port for bubble curtain vessel.
4. Helicopter transit emissions assume two round trips per week, with a duration of 30 minutes per round trip, based on travel from JFK Int'l Airport (30 mi one-way distance, 1.5 mi over Queens County, 8.5 mi over Nassau County, and 20 mi inside OCS radius).
5. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
6. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
7. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
8. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
9. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the $PM_{2.5}$ or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
10. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
11. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-6. EW 2 Foundation Construction Emissions (Monopile Design)

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Helicopter - Twin-Engine Heavy		N/A							
Main Engines	2			164	1,400	Jet fuel	N/A	N/A	N/A
Main Installation Vessel		1	661 x 290 x 162 (43)						
Main Engines	6			1.31	6,568	Diesel	86,000	52,000	3.18
Main Engines	4			1.31	6,032	Diesel			
Main Engines	2			1.31	7,373	Diesel			
Motion Compensated Gripper Frame Generator	1	N/A	N/A	4.02	2,188	Diesel	0	8,343	3.18
Heavy Transport Vessel 1		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Heavy Transport Vessel 2		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Heavy Transport Vessel 3		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Fall Pipe Vessel - Seabed filter layer		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
Fall Pipe Vessel - Scour protection		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
Anchor Handling Tug		1	236 x 59 x 27 (24)						
Main Engines	4			1.31	4,021	Diesel	42,000	10,000	3.18
Bubble Curtain Vessel		N/A	150 x 36 x 10						
Main Engines	2			2.07	750	Diesel	4,000	4,000	3.18
Aux. Engine	1			2.04	133	Diesel			
Bow Thruster Engine	1			2.04	325	Diesel			
Aux. Engine	1			2.04	133	Diesel			
Crew Transfer Vessel 1 (Primary)		N/A	65 x 17 x 5						
Main Engines	2			4.02	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			3.03	27	Diesel			
Protected Species Observer (PSO) Vessel		N/A	65 x 17 x 5						
Main Engines	2			2.06	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			2.03	27	Diesel			
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-6. EW 2 Foundation Construction Emissions (Monopile Design)

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Helicopter - Twin-Engine Heavy										
Main Engines	26	0.5	0	0	0	0	100%	0%	4,092	0
Main Installation Vessel										
Main Engines	1	6	0	142	24	3,408	30%	18%	6,761	2,322,013
Main Engines	1	6	0	142	24	3,408	30%	18%		
Main Engines	1	6	0	142	24	3,408	30%	18%		
Motion Compensated Gripper Frame Generator										
	0	0	0	30	24	720	0%	100%	0	78,708
Heavy Transport Vessel 1										
Main Engines	6	6	0	37	24	888	44%	8%	25,943	116,352
Main Engines	6	6	0	37	24	888	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Transport Vessel 2										
Main Engines	6	6	0	37	24	888	44%	8%	25,943	116,352
Main Engines	6	6	0	37	24	888	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Transport Vessel 3										
Main Engines	6	6	0	37	24	888	44%	8%	25,943	116,352
Main Engines	6	6	0	37	24	888	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Fall Pipe Vessel - Seabed filter layer										
Main Engines	18	6	0	142	24	3,408	69%	14%	70,755	446,541
Aux. Engine	18	6	0	142	24	3,408	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Fall Pipe Vessel - Scour protection										
Main Engines	18	6	0	142	24	3,408	69%	14%	70,755	446,541
Aux. Engine	18	6	0	142	24	3,408	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Anchor Handling Tug										
Main Engines	13	9	0	142	24	3,408	71%	17%	64,387	446,541
Bubble Curtain Vessel										
Main Engines	3	9	0	142	24	3,408	64%	50%	1,415	178,616
Aux. Engine	3	9	0	142	24	3,408	64%	50%		
Bow Thruster Engine	0	0	0	142	24	3,408	0%	50%		
Aux. Engine	0	0	0	142	24	3,408	0%	50%		
Crew Transfer Vessel 1 (Primary)										
Main Engines	13	9	0	142	24	3,408	64%	51%	7,665	178,616
Main Engines	13	9	0	142	24	3,408	64%	51%		
Protected Species Observer (PSO) Vessel										
Main Engines	13	9	0	142	24	3,408	64%	51%	7,665	178,616
Main Engines	13	9	0	142	24	3,408	64%	51%		
TOTALS									**311,324**	**4,625,248**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-6. EW 2 Foundation Construction Emissions (Monopile Design)

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Main Installation Vessel													
Main Engines	10.52	263.84	21.99	3.73	3.43	8.01	0.92	4.29E-04	2.76E-01	13,136.71	0.20	0.58	13,314.44
Main Engines	6.44	161.54	13.46	2.29	2.10	4.90	0.56	2.63E-04	1.69E-01	8,042.88	0.12	0.35	8,151.70
Main Engines	3.94	98.72	8.23	1.40	1.28	3.00	0.34	1.61E-04	1.03E-01	4,915.10	0.07	0.22	4,981.59
Motion Compensated Gripper Frame Generator	0.19	1.74	4.83	0.04	0.04	6.04E-03	0.02	4.10E-06	2.08E-04	656.55	7.92E-03	3.21E-02	666.32
Heavy Transport Vessel 1													
Main Engines	3.74	4.61	8.88	0.33	0.31	0.71	0.31	3.81E-05	0.02	1,167.41	1.78E-02	0.05	1,183.20
Main Engines	0.07	1.21	1.03	0.03	0.03	1.28E-03	6.00E-03	3.48E-06	4.41E-05	139.45	0.00	6.82E-03	141.54
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 2													
Main Engines	3.74	4.61	8.88	0.33	0.31	0.71	0.31	3.81E-05	0.02	1,167.41	1.78E-02	0.05	1,183.20
Main Engines	0.07	1.21	1.03	0.03	0.03	1.28E-03	6.00E-03	3.48E-06	4.41E-05	139.45	0.00	6.82E-03	141.54
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 3													
Main Engines	3.74	4.61	8.88	0.33	0.31	0.71	0.31	3.81E-05	0.02	1,167.41	1.78E-02	0.05	1,183.20
Main Engines	0.07	1.21	1.03	0.03	0.03	1.28E-03	6.00E-03	3.48E-06	4.41E-05	139.45	0.00	6.82E-03	141.54
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Seabed filter layer													
Main Engines	3.68	92.27	7.69	1.31	1.20	2.80	0.32	1.50E-04	0.10	4,593.93	0.07	0.20	4,656.08
Aux. Engine	0.09	6.55	1.54	0.19	0.19	3.88E-03	0.01	2.33E-05	1.34E-04	422.17	0.00	2.06E-02	428.36
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	3.68	92.27	7.69	1.31	1.20	2.80	0.32	1.50E-04	0.10	4,593.93	0.07	0.20	4,656.08
Aux. Engine	0.09	6.55	1.54	0.19	0.19	3.88E-03	0.01	2.33E-05	1.34E-04	422.17	0.00	2.06E-02	428.36
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Anchor Handling Tug													
Main Engines	4.02	100.79	8.40	1.43	1.31	3.06	0.35	1.64E-04	0.11	5,018.21	0.08	0.22	5,086.10
Bubble Curtain Vessel													
Main Engines	0.80	14.42	10.54	0.42	0.41	1.32E-02	0.07	5.11E-05	4.53E-04	1,432.76	0.02	0.07	1,454.07
Aux. Engine	0.07	1.33	0.93	0.07	0.07	1.17E-03	7.50E-03	9.07E-06	4.02E-05	127.04	0.00	6.21E-03	128.93
Bow Thruster Engine	0.18	3.26	2.28	0.18	0.18	2.85E-03	1.83E-02	2.22E-05	9.82E-05	310.43	0.00	1.52E-02	315.05
Aux. Engine	0.07	1.33	0.93	0.07	0.07	1.17E-03	7.50E-03	9.07E-06	4.02E-05	127.04	0.00	6.21E-03	128.93
Crew Transfer Vessel 1 (Primary)													
Main Engines	0.57	5.15	14.31	0.11	0.11	0.02	0.05	1.39E-05	6.15E-04	1,945.12	0.02	0.10	1,974.05
Main Engines	1.90E-02	0.34	0.38	0.02	0.02	4.79E-04	2.01E-03	2.79E-06	1.65E-05	52.15	6.29E-04	2.55E-03	52.92
Protected Species Observer (PSO) Vessel													
Main Engines	1.09	19.58	14.31	0.57	0.56	0.02	0.10	6.94E-05	6.15E-04	1,945.12	0.02	0.10	1,974.05
Main Engines	3.08E-02	0.55	0.42	0.05	0.04	4.79E-04	3.43E-03	5.58E-06	1.65E-05	52.15	6.29E-04	2.55E-03	52.92
TOTALS	**46.91**	**887.69**	**149.22**	**14.47**	**13.41**	**26.78**	**4.07**	**1.68E-03**	**0.92**	**51,714.03**	**0.76**	**2.32**	**52,424.19**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-6. EW 2 Foundation Construction Emissions (Monopile Design)

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0.02	0.23	5.33E-03	5.20E-03	5.20E-03	1.37E-02	4.50E-04	2.17E-07	4.72E-04	43.16	1.24E-03	1.43E-03	43.62
Main Installation Vessel													
Main Engines	3.06E-02	0.77	0.06	0.01	0.01	2.33E-02	2.68E-03	1.25E-06	8.03E-04	38.25	5.82E-04	1.69E-03	38.77
Main Engines	1.88E-02	0.47	0.04	0.01	0.01	1.43E-02	1.64E-03	7.65E-07	4.91E-04	23.42	3.56E-04	1.03E-03	23.74
Main Engines	1.15E-02	0.29	0.02	4.07E-03	3.74E-03	8.73E-03	1.00E-03	4.68E-07	3.00E-04	14.31	2.18E-04	6.31E-04	14.50
Motion Compensated Gripper Frame Generator													
0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 1													
Main Engines	0.83	1.03	1.98	0.07	0.07	0.16	0.07	8.51E-06	5.46E-03	260.30	3.96E-03	1.15E-02	263.82
Main Engines	1.49E-02	0.27	0.23	6.41E-03	6.21E-03	2.86E-04	1.34E-03	7.77E-07	9.83E-06	31.09	4.58E-04	1.52E-03	31.56
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 2													
Main Engines	0.83	1.03	1.98	0.07	0.07	0.16	0.07	8.51E-06	5.46E-03	260.30	3.96E-03	1.15E-02	263.82
Main Engines	1.49E-02	0.27	0.23	6.41E-03	6.21E-03	2.86E-04	1.34E-03	7.77E-07	9.83E-06	31.09	4.58E-04	1.52E-03	31.56
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel 3													
Main Engines	0.83	1.03	1.98	0.07	0.07	0.16	0.07	8.51E-06	5.46E-03	260.30	3.96E-03	1.15E-02	263.82
Main Engines	1.49E-02	0.27	0.23	6.41E-03	6.21E-03	2.86E-04	1.34E-03	7.77E-07	9.83E-06	31.09	4.58E-04	1.52E-03	31.56
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Seabed filter layer													
Main Engines	0.58	14.62	1.22	0.21	0.19	0.44	0.05	2.38E-05	0.02	727.91	1.11E-02	0.03	737.76
Aux. Engine	0.01	1.04	0.24	0.03	0.03	6.15E-04	1.75E-03	3.69E-06	2.12E-05	66.89	2.66E-04	3.27E-03	67.87
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	0.58	14.62	1.22	0.21	0.19	0.44	0.05	2.38E-05	0.02	727.91	1.11E-02	0.03	737.76
Aux. Engine	0.01	1.04	0.24	0.03	0.03	6.15E-04	1.75E-03	3.69E-06	2.12E-05	66.89	2.66E-04	3.27E-03	67.87
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Anchor Handling Tug													
Main Engines	0.58	14.53	1.21	0.21	0.19	0.44	0.05	2.36E-05	0.02	723.58	1.10E-02	0.03	733.37
Bubble Curtain Vessel													
Main Engines	8.11E-03	0.15	0.11	4.28E-03	4.15E-03	1.34E-04	7.42E-04	5.19E-07	4.60E-06	14.53	1.75E-04	7.11E-04	14.75
Aux. Engine	7.49E-04	1.35E-02	9.48E-03	7.59E-04	7.36E-04	1.18E-05	7.61E-05	9.20E-08	4.08E-07	1.29	1.56E-05	6.30E-05	1.31
Bow Thruster Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Crew Transfer Vessel 1 (Primary)													
Main Engines	0.02	0.22	0.61	0.00	0.00	7.67E-04	2.08E-03	5.96E-07	2.64E-05	83.47	1.01E-03	4.08E-03	84.71
Main Engines	8.15E-04	0.01	0.02	9.88E-04	9.58E-04	2.06E-05	8.61E-05	1.20E-07	7.08E-07	2.24	2.70E-05	1.09E-04	2.27
Protected Species Observer (PSO) Vessel													
Main Engines	0.05	0.84	0.61	0.02	0.02	7.67E-04	4.26E-03	2.98E-06	2.64E-05	83.47	1.01E-03	4.08E-03	84.71
Main Engines	1.32E-03	0.02	0.02	1.98E-03	1.92E-03	2.06E-05	1.47E-04	2.40E-07	7.08E-07	2.24	2.70E-05	1.09E-04	2.27
TOTALS	**4.48**	**52.75**	**12.28**	**0.99**	**0.91**	**1.87**	**0.38**	**1.14E-04**	**0.06**	**3,493.75**	**0.05**	**0.16**	**3,541.43**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)\ *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-6. EW 2 Foundation Construction Emissions (Monopile Design)

Notes:

1. Emission calculations provided in this assessment are based on development of up to 90 wind turbine locations for EW 2.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
   Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
3. The number of transits for each vessel are based on the following assumptions:
   6 round trips to/from overseas port for each heavy transport vessel.
   1 round trip to/from overseas port for the heavy lift installation vessel.
   18 round trips to/from overseas port for each fall pipe vessel (based on assumed capacity to treat 5 foundations per cargo).
   Weekly round trips to/from port for the anchor handling tug and crew transfer vessel. Monthly round trips to/from port for bubble curtain vessel.
4. Helicopter transit emissions assume two round trips per week, with a duration of 30 minutes per round trip, based on travel from JFK Int'l Airport (30 mi one-way distance, 1.5 mi over Queens County, 8.5 mi over Nassau County, and 20 mi inside OCS radius).
5. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
6. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
7. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
8. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
9. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the $PM_{2.5}$ or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
10. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
11. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-7. EW 1 Offshore Substation Topside and Foundation Installation Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Heavy Transport Vessel (OSS Jacket)		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Heavy Transport Vessel (OSS Topside)		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Heavy Lift Vessel - Jacket/topside installation		1	661 x 290 x 162 (43)						
Main Engines	6			1.31	6,568	Diesel	86,000	52,000	3.18
Main Engines	4			1.31	6,032	Diesel			
Main Engines	2			1.31	7,373	Diesel			
Anchor Handling Tug		1	236 x 59 x 27 (24)						
Main Engines	4			1.31	4,021	Diesel	42,000	10,000	3.18
Fall Pipe Vessel -Filter layer		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
Fall Pipe Vessel - Scour protection		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
Bubble Curtain Vessel		N/A	150 x 36 x 10						
Main Engines	2			2.07	750	Diesel	4,000	4,000	3.18
Aux. Engine	1			2.04	133	Diesel			
Bow Thruster Engine	1			2.04	325	Diesel			
Aux. Engine	1			2.04	133	Diesel			
OSS Installation Generator Engine	1	N/A	N/A	255	469	Diesel	0	1,722	3.18
OSS Commissioning Generator Engine	1	N/A	N/A	1.21	1,005	Diesel	0	3,850	3.18
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-7. EW 1 Offshore Substation Topside and Foundation Installation Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Heavy Transport Vessel (OSS Jacket)										
Main Engines	1	200	0	7	24	168	44%	8%	144,130	22,013
Main Engines	1	200	0	7	24	168	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Transport Vessel (OSS Topside)										
Main Engines	1	200	0	8	24	192	44%	8%	144,130	25,157
Main Engines	1	200	0	8	24	192	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Lift Vessel - Jacket/topside installation										
Main Engines	1	6	0	15	24	360	30%	18%	6,761	245,283
Main Engines	1	6	0	15	24	360	30%	18%		
Main Engines	1	6	0	15	24	360	30%	18%		
Anchor Handling Tug										
Main Engines	1	6	0	15	24	360	71%	17%	3,302	47,170
Fall Pipe Vessel -Filter layer										
Main Engines	1	6	0	4	24	96	69%	14%	3,931	12,579
Aux. Engine	1	6	0	4	24	96	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Fall Pipe Vessel - Scour protection										
Main Engines	1	6	0	4	24	96	69%	14%	3,931	12,579
Aux. Engine	1	6	0	4	24	96	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Bubble Curtain Vessel										
Main Engines	1	9	0	7	24	168	64%	50%	472	8,805
Aux. Engine	1	9	0	7	24	168	64%	50%		
Bow Thruster Engine	0	0	0	7	24	168	0%	50%		
Aux. Engine	0	0	0	7	24	168	0%	50%		
OSS Installation Generator Engine	0	0	0	60	24	1,440	0%	100%	0	32,491
OSS Commissioning Generator Engine	0	0	0	400	24	9,600	0%	100%	0	484,277
TOTALS									**306,656**	**890,352**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-7. EW 1 Offshore Substation Topside and Foundation Installation Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Heavy Transport Vessel (OSS Jacket)													
Main Engines	0.71	0.87	1.68	0.06	0.06	0.13	0.06	7.22E-06	4.63E-03	220.86	3.36E-03	9.75E-03	223.85
Main Engines	1.27E-02	0.23	0.19	5.44E-03	5.27E-03	2.43E-04	1.13E-03	6.59E-07	8.34E-06	26.38	3.88E-04	1.29E-03	26.78
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel (OSS Topside)													
Main Engines	0.81	1.00	1.92	0.07	0.07	0.15	0.07	8.25E-06	5.30E-03	252.41	3.84E-03	1.11E-02	255.83
Main Engines	1.45E-02	0.26	0.22	6.21E-03	6.03E-03	2.77E-04	1.30E-03	7.53E-07	9.54E-06	30.15	4.44E-04	1.47E-03	30.60
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel - Jacket/topside installation													
Main Engines	1.11	27.87	2.32	0.39	0.36	0.85	0.10	4.53E-05	0.03	1,387.68	2.11E-02	0.06	1,406.46
Main Engines	0.68	17.06	1.42	0.24	0.22	0.52	0.06	2.78E-05	0.02	849.60	1.29E-02	0.04	861.10
Main Engines	0.42	10.43	0.87	0.15	0.14	0.32	0.04	1.70E-05	1.09E-02	519.20	7.90E-03	0.02	526.22
Anchor Handling Tug													
Main Engines	0.42	10.65	0.89	0.15	0.14	0.32	0.04	1.73E-05	1.11E-02	530.09	8.07E-03	0.02	537.26
Fall Pipe Vessel -Filter layer													
Main Engines	0.10	2.60	0.22	0.04	0.03	0.08	9.08E-03	4.23E-06	2.72E-03	129.41	1.97E-03	5.71E-03	131.16
Aux. Engine	2.47E-03	0.18	0.04	5.41E-03	5.25E-03	1.09E-04	3.11E-04	6.56E-07	3.76E-06	11.89	4.73E-05	5.82E-04	12.07
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	0.10	2.60	0.22	0.04	0.03	0.08	9.08E-03	4.23E-06	2.72E-03	129.41	1.97E-03	5.71E-03	131.16
Aux. Engine	2.47E-03	0.18	0.04	5.41E-03	5.25E-03	1.09E-04	3.11E-04	6.56E-07	3.76E-06	11.89	4.73E-05	5.82E-04	12.07
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Bubble Curtain Vessel													
Main Engines	0.04	0.71	0.52	0.02	0.02	6.49E-04	3.61E-03	2.52E-06	2.23E-05	70.63	8.52E-04	3.45E-03	71.68
Aux. Engine	3.64E-03	0.07	0.05	3.69E-03	3.58E-03	5.76E-05	3.70E-04	4.47E-07	1.98E-06	6.26	7.56E-05	3.06E-04	6.36
Bow Thruster Engine	8.89E-03	0.16	0.11	9.01E-03	8.74E-03	1.41E-04	9.03E-04	1.09E-06	4.84E-06	15.30	1.85E-04	7.48E-04	15.53
Aux. Engine	3.64E-03	0.07	0.05	3.69E-03	3.58E-03	5.76E-05	3.70E-04	4.47E-07	1.98E-06	6.26	7.56E-05	3.06E-04	6.36
OSS Installation Generator Engine	0.14	2.48	2.78	0.02	0.02	8.33E-04	8.56E-03	1.69E-06	2.87E-05	90.58	3.67E-03	7.35E-04	90.89
OSS Commissioning Generator Engine	1.12	84.08	19.76	2.46	2.39	0.05	0.14	2.99E-04	1.71E-03	5,415.12	0.02	0.26	5,494.58
TOTALS	**5.71**	**161.50**	**33.30**	**3.68**	**3.51**	**2.50**	**0.53**	**4.39E-04**	**0.09**	**9,703.14**	**0.09**	**0.45**	**9,839.94**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-7. EW 1 Offshore Substation Topside and Foundation Installation Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Heavy Transport Vessel (OSS Jacket)													
Main Engines	4.63	5.71	11.00	0.41	0.38	0.88	0.38	4.73E-05	0.03	1,446.11	2.20E-02	0.06	1,465.68
Main Engines	0.08	1.50	1.27	0.04	0.03	1.59E-03	7.43E-03	4.32E-06	5.46E-05	172.75	0.00	8.45E-03	175.33
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel (OSS Topside)													
Main Engines	4.63	5.71	11.00	0.41	0.38	0.88	0.38	4.73E-05	0.03	1,446.11	2.20E-02	0.06	1,465.68
Main Engines	0.08	1.50	1.27	0.04	0.03	1.59E-03	7.43E-03	4.32E-06	5.46E-05	172.75	0.00	8.45E-03	175.33
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel - Jacket/topside installation													
Main Engines	0.03	0.77	0.06	1.09E-02	1.00E-02	0.02	2.68E-03	1.25E-06	8.03E-04	38.25	5.82E-04	1.69E-03	38.77
Main Engines	0.02	0.47	0.04	6.65E-03	6.12E-03	1.43E-02	1.64E-03	7.65E-07	4.91E-04	23.42	3.56E-04	1.03E-03	23.74
Main Engines	1.15E-02	0.29	0.02	4.07E-03	3.74E-03	8.73E-03	1.00E-03	4.68E-07	3.00E-04	14.31	2.18E-04	6.31E-04	14.50
Anchor Handling Tug													
Main Engines	0.03	0.75	0.06	1.05E-02	9.70E-03	0.02	2.60E-03	1.21E-06	7.79E-04	37.11	5.65E-04	1.64E-03	37.61
Fall Pipe Vessel -Filter layer													
Main Engines	0.03	0.81	0.07	1.15E-02	1.06E-02	0.02	2.84E-03	1.32E-06	8.48E-04	40.44	6.15E-04	1.78E-03	40.99
Aux. Engine	7.72E-04	0.06	0.01	1.69E-03	1.64E-03	3.42E-05	9.71E-05	2.05E-07	1.18E-06	3.72	1.48E-05	1.82E-04	3.77
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	0.03	0.81	0.07	1.15E-02	1.06E-02	0.02	2.84E-03	1.32E-06	8.48E-04	40.44	6.15E-04	1.78E-03	40.99
Aux. Engine	7.72E-04	0.06	0.01	1.69E-03	1.64E-03	3.42E-05	9.71E-05	2.05E-07	1.18E-06	3.72	1.48E-05	1.82E-04	3.77
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Bubble Curtain Vessel													
Main Engines	2.70E-03	0.05	0.04	1.43E-03	1.38E-03	4.45E-05	2.47E-04	1.73E-07	1.53E-06	4.84	5.85E-05	2.37E-04	4.92
Aux. Engine	2.50E-04	4.50E-03	3.16E-03	2.53E-04	2.45E-04	3.95E-06	2.54E-05	3.07E-08	1.36E-07	0.43	5.18E-06	2.10E-05	0.44
Bow Thruster Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
OSS Installation Generator Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
OSS Commissioning Generator Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**9.59**	**18.49**	**24.94**	**0.95**	**0.88**	**1.89**	**0.79**	**1.10E-04**	**0.06**	**3,444.39**	**0.05**	**0.15**	**3,491.50**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:

HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-7. EW 1 Offshore Substation Topside and Foundation Installation Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 57 wind turbine locations for EW 1.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances: Texas port to center of OCS lease area:
    - 2,000 nm (30 nm in TX state waters, 1,940 nm in non-OCS federal waters, and 30 nm within OCS radius)
    - South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
    - Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
3. The number of transits for each vessel are based on the following assumptions:
    - 1 round trip to/from overseas port for the heavy transport vessels and heavy lift vessel.
    - 1 round trips to/from overseas port for the fall pipe vessel.
    - 1 round trip to/from port for bubble curtain vessel and tugs.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
6. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
8. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
9. OSS installation generator engine will be a portable generator lifted onto OSS platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
10. OSS commissioning generator engine could be a vessel engine connected directly to OSS platform; emissions based on factors for Category 2 marine engines.
11. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
12. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-8. EW 2 Offshore Substation Topside and Foundation Installation Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Heavy Transport Vessel (OSS Jacket)		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Heavy Transport Vessel (OSS Topside)		1	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Heavy Lift Vessel - Jacket/topside installation		1	661 x 290 x 162 (43)						
Main Engines	6			1.31	6,568	Diesel	86,000	52,000	3.18
Main Engines	4			1.31	6,032	Diesel			
Main Engines	2			1.31	7,373	Diesel			
Anchor Handling Tug		1	236 x 59 x 27 (24)						
Main Engines	4			1.31	4,021	Diesel	42,000	10,000	3.18
Fall Pipe Vessel -Filter layer		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
Fall Pipe Vessel - Scour protection		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
Bubble Curtain Vessel		N/A	150 x 36 x 10						
Main Engines	2			2.07	750	Diesel	4,000	4,000	3.18
Aux. Engine	1			2.04	133	Diesel			
Bow Thruster Engine	1			2.04	325	Diesel			
Aux. Engine	1			2.04	133	Diesel			
OSS Installation Generator Engine	1	N/A	N/A	255	469	Diesel	0	1,722	3.18
OSS Commissioning Generator Engine	1	N/A	N/A	1.21	1,005	Diesel	0	3,850	3.18
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-8. EW 2 Offshore Substation Topside and Foundation Installation Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Heavy Transport Vessel (OSS Jacket)										
Main Engines	1	200	0	7	24	168	44%	8%	144,130	22,013
Main Engines	1	200	0	7	24	168	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Transport Vessel (OSS Topside)										
Main Engines	1	200	0	8	24	192	44%	8%	144,130	25,157
Main Engines	1	200	0	8	24	192	44%	8%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Lift Vessel - Jacket/topside installation										
Main Engines	1	6	0	15	24	360	30%	18%	6,761	245,283
Main Engines	1	6	0	15	24	360	30%	18%		
Main Engines	1	6	0	15	24	360	30%	18%		
Anchor Handling Tug										
Main Engines	1	6	0	15	24	360	71%	17%	3,302	47,170
Fall Pipe Vessel -Filter layer										
Main Engines	1	6	0	4	24	96	69%	14%	3,931	12,579
Aux. Engine	1	6	0	4	24	96	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Fall Pipe Vessel - Scour protection										
Main Engines	1	6	0	4	24	96	69%	14%	3,931	12,579
Aux. Engine	1	6	0	4	24	96	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Bubble Curtain Vessel										
Main Engines	1	9	0	7	24	168	64%	50%	472	8,805
Aux. Engine	1	9	0	7	24	168	64%	50%		
Bow Thruster Engine	0	0	0	7	24	168	0%	50%		
Aux. Engine	0	0	0	7	24	168	0%	50%		
OSS Installation Generator Engine	0	0	0	60	24	1,440	0%	100%	0	32,491
OSS Commissioning Generator Engine	0	0	0	700	24	16,800	0%	100%	0	847,484
TOTALS									**306,656**	**1,253,560**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-8. EW 2 Offshore Substation Topside and Foundation Installation Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Heavy Transport Vessel (OSS Jacket)													
Main Engines	0.71	0.87	1.68	0.06	0.06	0.13	0.06	7.22E-06	4.63E-03	220.86	3.36E-03	9.75E-03	223.85
Main Engines	1.27E-02	0.23	0.19	5.44E-03	5.27E-03	2.43E-04	1.13E-03	6.59E-07	8.34E-06	26.38	3.88E-04	1.29E-03	26.78
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel (OSS Topside)													
Main Engines	0.81	1.00	1.92	0.07	0.07	0.15	0.07	8.25E-06	5.30E-03	252.41	3.84E-03	1.11E-02	255.83
Main Engines	1.45E-02	0.26	0.22	6.21E-03	6.03E-03	2.77E-04	1.30E-03	7.53E-07	9.54E-06	30.15	4.44E-04	1.47E-03	30.60
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel - Jacket/topside installation													
Main Engines	1.11	27.87	2.32	0.39	0.36	0.85	0.10	4.53E-05	0.03	1,387.68	2.11E-02	0.06	1,406.46
Main Engines	0.68	17.06	1.42	0.24	0.22	0.52	0.06	2.78E-05	0.02	849.60	1.29E-02	0.04	861.10
Main Engines	0.42	10.43	0.87	0.15	0.14	0.32	0.04	1.70E-05	1.09E-02	519.20	7.90E-03	0.02	526.22
Anchor Handling Tug													
Main Engines	0.42	10.65	0.89	0.15	0.14	0.32	0.04	1.73E-05	1.11E-02	530.09	8.07E-03	0.02	537.26
Fall Pipe Vessel -Filter layer													
Main Engines	0.10	2.60	0.22	0.04	0.03	0.08	9.08E-03	4.23E-06	2.72E-03	129.41	1.97E-03	5.71E-03	131.16
Aux. Engine	2.47E-03	0.18	0.04	5.41E-03	5.25E-03	1.09E-04	3.11E-04	6.56E-07	3.76E-06	11.89	4.73E-05	5.82E-04	12.07
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	0.10	2.60	0.22	0.04	0.03	0.08	9.08E-03	4.23E-06	2.72E-03	129.41	1.97E-03	5.71E-03	131.16
Aux. Engine	2.47E-03	0.18	0.04	5.41E-03	5.25E-03	1.09E-04	3.11E-04	6.56E-07	3.76E-06	11.89	4.73E-05	5.82E-04	12.07
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Bubble Curtain Vessel													
Main Engines	0.04	0.71	0.52	0.02	0.02	6.49E-04	3.61E-03	2.52E-06	2.23E-05	70.63	8.52E-04	3.45E-03	71.68
Aux. Engine	3.64E-03	0.07	0.05	3.69E-03	3.58E-03	5.76E-05	3.70E-04	4.47E-07	1.98E-06	6.26	7.56E-05	3.06E-04	6.36
Bow Thruster Engine	8.89E-03	0.16	0.11	9.01E-03	8.74E-03	1.41E-04	9.03E-04	1.09E-06	4.84E-06	15.30	1.85E-04	7.48E-04	15.53
Aux. Engine	3.64E-03	0.07	0.05	3.69E-03	3.58E-03	5.76E-05	3.70E-04	4.47E-07	1.98E-06	6.26	7.56E-05	3.06E-04	6.36
OSS Installation Generator Engine	0.14	2.48	2.78	0.02	0.02	8.33E-04	8.56E-03	1.69E-06	2.87E-05	90.58	3.67E-03	7.35E-04	90.89
OSS Commissioning Generator Engine	1.97	147.14	34.59	4.31	4.18	0.09	0.25	5.23E-04	3.00E-03	9,476.47	0.04	0.46	9,615.51
TOTALS	**6.55**	**224.56**	**48.13**	**5.53**	**5.30**	**2.54**	**0.64**	**6.63E-04**	**0.09**	**13,764.49**	**0.10**	**0.65**	**13,960.87**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-8. EW 2 Offshore Substation Topside and Foundation Installation Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Heavy Transport Vessel (OSS Jacket)													
Main Engines	4.63	5.71	11.00	0.41	0.38	0.88	0.38	4.73E-05	0.03	1,446.11	2.20E-02	0.06	1,465.68
Main Engines	0.08	1.50	1.27	0.04	0.03	1.59E-03	7.43E-03	4.32E-06	5.46E-05	172.75	0.00	8.45E-03	175.33
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Transport Vessel (OSS Topside)													
Main Engines	4.63	5.71	11.00	0.41	0.38	0.88	0.38	4.73E-05	0.03	1,446.11	2.20E-02	0.06	1,465.68
Main Engines	0.08	1.50	1.27	0.04	0.03	1.59E-03	7.43E-03	4.32E-06	5.46E-05	172.75	0.00	8.45E-03	175.33
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel - Jacket/topside installation													
Main Engines	0.03	0.77	0.06	1.09E-02	1.00E-02	0.02	2.68E-03	1.25E-06	8.03E-04	38.25	5.82E-04	1.69E-03	38.77
Main Engines	0.02	0.47	0.04	6.65E-03	6.12E-03	1.43E-02	1.64E-03	7.65E-07	4.91E-04	23.42	3.56E-04	1.03E-03	23.74
Main Engines	1.15E-02	0.29	0.02	4.07E-03	3.74E-03	8.73E-03	1.00E-03	4.68E-07	3.00E-04	14.31	2.18E-04	6.31E-04	14.50
Anchor Handling Tug													
Main Engines	0.03	0.75	0.06	0.01	0.01	2.26E-02	2.60E-03	1.21E-06	7.79E-04	37.11	5.65E-04	1.64E-03	37.61
Fall Pipe Vessel -Filter layer													
Main Engines	0.03	0.81	0.07	1.15E-02	1.06E-02	0.02	2.84E-03	1.32E-06	8.48E-04	40.44	6.15E-04	1.78E-03	40.99
Aux. Engine	7.72E-04	0.06	0.01	1.69E-03	1.64E-03	3.42E-05	9.71E-05	2.05E-07	1.18E-06	3.72	1.48E-05	1.82E-04	3.77
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	0.03	0.81	0.07	1.15E-02	1.06E-02	0.02	2.84E-03	1.32E-06	8.48E-04	40.44	6.15E-04	1.78E-03	40.99
Aux. Engine	7.72E-04	0.06	0.01	1.69E-03	1.64E-03	3.42E-05	9.71E-05	2.05E-07	1.18E-06	3.72	1.48E-05	1.82E-04	3.77
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Bubble Curtain Vessel													
Main Engines	2.70E-03	0.05	0.04	1.43E-03	1.38E-03	4.45E-05	2.47E-04	1.73E-07	1.53E-06	4.84	5.85E-05	2.37E-04	4.92
Aux. Engine	2.50E-04	4.50E-03	3.16E-03	2.53E-04	2.45E-04	3.95E-06	2.54E-05	3.07E-08	1.36E-07	0.43	5.18E-06	2.10E-05	0.44
Bow Thruster Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
OSS Installation Generator Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
OSS Commissioning Generator Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**9.59**	**18.49**	**24.94**	**0.95**	**0.88**	**1.89**	**0.79**	**1.10E-04**	**0.06**	**3,444.39**	**0.05**	**0.15**	**3,491.50**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons = \frac{(N) * (hp) * (Load\ \%) * (Trips) * (Time) * (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb) * (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-8. EW 2 Offshore Substation Topside and Foundation Installation Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 90 wind turbine locations for EW 2.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances: Texas port to center of OCS lease area:
   - 2,000 nm (30 nm in TX state waters, 1,940 nm in non-OCS federal waters, and 30 nm within OCS radius)
   - South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
   - Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
3. The number of transits for each vessel are based on the following assumptions:
   - 1 round trip to/from overseas port for the heavy transport vessels and heavy lift vessel.
   - 1 round trips to/from overseas port for the fall pipe vessel.
   - 1 round trip to/from port for bubble curtain vessel and tugs.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
6. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
8. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
9. OSS installation generator engine will be a portable generator lifted onto OSS platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
10. OSS commissioning generator engine could be a vessel engine connected directly to OSS platform; emissions based on factors for Category 2 marine engines.
11. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
12. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Helicopter - Twin-Engine Heavy		N/A							
Main Engines	2			164	1,400	Jet fuel	N/A	N/A	N/A
Export Cable Lay Barge (Near-shore)		2	413 x 108 x 22 (11)						
Main Engines	3			1.21	1,408	Diesel	9,000	9,000	3.18
Flushing System Pump Engines	2			1.21	1,206	Diesel			
Emergency Engine	1			1.12	168	Diesel			
Heavy Lift Vessel - Cable Spool Transport		1	715 x 184 x 41 (32)						
Main Engines	4			1.31	9,651	Diesel	50,000	50,000	3.18
Export Cable Lay Vessel (Mid-shore)		1	388 x 105 x 26 (18)						
Stern Thruster Engines	2			2.09	2,640	Diesel	15,000	15,000	3.18
Bow Thruster Engines	2			2.09	2,500	Diesel			
Main Engines	4			2.07	536	Diesel			
Emergency Engine	1			2.05	94	Diesel			
Export Cable Lay Vessel (Far-shore)		1	492 x 102 x 42 (29)						
Main Engines	6			5.02	4,625	Diesel	20,000	20,000	3.18
Tender Support Vessel		1	243 x 56 x 26 (21)						
Main Engines	2			3.20	2,466	Diesel	15,000	15,000	3.18
Main Engines	2			3.20	1,850	Diesel			
Emergency Engine	1			3.07	382	Diesel			
Inter-Array Cable Lay Vessel		1	313 x 71 x 29 (24)						
Main Engines	4			2.09	2,606	Diesel	15,000	15,000	3.18
Installation Support Vessel		1	243 x 56 x 26 (21)						
Main Engines	2			2.09	2,466	Diesel	15,000	15,000	3.18
Main Engines	2			2.09	1,850	Diesel			
Emergency Engine	1			2.07	382	Diesel			
Fall Pipe Vessel - Scour protection		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Helicopter - Twin-Engine Heavy										
Main Engines	60	0.5	0	0	0	0	100%	0%	9,442	0
Export Cable Lay Barge (Near-shore)										
Main Engines	2	9	24	14	24	912	56%	56%	2,123	107,547
Flushing System Pump Engines	0	0	0	0	0	0	0%	0%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Heavy Lift Vessel - Cable Spool Transport										
Main Engines	2	129	44	14	24	1,392	35%	35%	169,025	911,950
Export Cable Lay Vessel (Mid-shore)										
Stern Thruster Engines	2	129	20	42	24	1,488	32%	32%	50,708	292,453
Bow Thruster Engines	2	129	20	42	24	1,488	32%	32%		
Main Engines	2	129	20	42	24	1,488	32%	32%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Export Cable Lay Vessel (Far-shore)										
Main Engines	2	129	10	132	24	3,408	20%	20%	67,610	893,082
Tender Support Vessel										
Main Engines	2	9	0	212	24	5,088	46%	46%	3,538	1,000,000
Main Engines	2	9	0	212	24	5,088	46%	46%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Inter-Array Cable Lay Vessel										
Main Engines	3	129	30	106	24	3,264	38%	38%	76,061	641,509
Installation Support Vessel										
Main Engines	2	9	0	106	24	2,544	46%	46%	3,538	500,000
Main Engines	2	9	0	106	24	2,544	46%	46%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Fall Pipe Vessel - Scour protection										
Main Engines	8	6	0	140	24	3,360	69%	14%	31,447	440,252
Aux. Engine	8	6	0	140	24	3,360	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
TOTALS									**424,654**	**5,313,836**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Lay Barge (Near-shore)													
Main Engines	0.25	18.67	4.39	0.55	0.53	1.11E-02	0.03	6.63E-05	3.80E-04	1,202.58	0.00	0.06	1,220.22
Flushing System Pump Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel - Cable Spool Transport													
Main Engines	8.21	205.83	17.15	2.91	2.68	6.25	0.72	3.35E-04	0.22	10,248.46	0.16	0.45	10,387.11
Export Cable Lay Vessel (Mid-shore)													
Stern Thruster Engines	0.94	16.90	10.23	1.02	0.99	1.28E-02	0.10	1.24E-04	4.40E-04	1,389.68	0.02	0.07	1,410.45
Bow Thruster Engines	0.89	16.01	9.68	0.97	0.94	1.21E-02	0.09	1.17E-04	4.16E-04	1,315.99	0.02	0.06	1,335.65
Main Engines	0.31	5.68	4.15	0.17	0.16	5.19E-03	0.03	2.01E-05	1.79E-04	564.50	0.01	0.03	572.90
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Lay Vessel (Far-shore)													
Main Engines	32.16	39.66	76.35	2.85	2.62	6.12	2.65	3.28E-04	0.21	10,036.42	0.15	0.44	10,172.21
Tender Support Vessel													
Main Engines	3.07	55.39	47.02	1.32	1.28	0.06	0.27	1.60E-04	2.02E-03	6,389.64	0.09	0.31	6,485.11
Main Engines	2.30	41.54	35.26	0.99	0.96	0.04	0.21	1.20E-04	1.52E-03	4,792.23	0.07	0.23	4,863.83
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-Array Cable Lay Vessel													
Main Engines	4.84	87.26	52.79	5.28	5.12	0.07	0.50	6.40E-04	2.27E-03	7,173.28	0.11	0.35	7,280.46
Installation Support Vessel													
Main Engines	2.15	38.86	23.51	2.35	2.28	0.03	0.22	2.85E-04	1.01E-03	3,194.82	0.05	0.16	3,242.56
Main Engines	1.62	29.15	17.63	1.76	1.71	0.02	0.17	2.14E-04	7.58E-04	2,396.12	0.04	0.12	2,431.92
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	3.63	90.97	7.58	1.29	1.18	2.76	0.32	1.48E-04	0.10	4,529.22	0.07	0.20	4,590.50
Aux. Engine	0.09	6.46	1.52	0.19	0.18	0.00	0.01	2.30E-05	1.32E-04	416.22	0.00	0.02	422.33
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**63.56**	**724.46**	**342.78**	**23.68**	**22.61**	**15.90**	**5.61**	**2.83E-03**	**0.55**	**59,546.21**	**0.85**	**2.79**	**60,398.58**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0.04	0.52	1.23E-02	1.20E-02	1.20E-02	0.03	1.04E-03	5.02E-07	1.09E-03	99.61	2.85E-03	3.30E-03	100.66
Export Cable Lay Barge (Near-shore)													
Main Engines	4.93E-03	0.37	0.09	0.01	0.01	2.18E-04	6.20E-04	1.31E-06	7.51E-06	23.74	9.43E-05	1.16E-03	24.08
Flushing System Pump Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel - Cable Spool Transport													
Main Engines	1.52	38.15	3.18	0.54	0.50	1.16	0.13	6.21E-05	0.04	1899.50	2.89E-02	0.08	1,925.20
Export Cable Lay Vessel (Mid-shore)													
Stern Thruster Engines	0.16	2.93	1.77	0.18	0.17	2.21E-03	1.68E-02	2.15E-05	7.62E-05	240.95	0.00	1.18E-02	244.55
Bow Thruster Engines	0.15	2.78	1.68	0.17	0.16	2.10E-03	1.59E-02	2.04E-05	7.22E-05	228.18	0.00	1.12E-02	231.58
Main Engines	0.05	0.99	0.72	0.03	0.03	9.00E-04	5.00E-03	3.49E-06	3.10E-05	97.88	1.18E-03	4.79E-03	99.33
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Lay Vessel (Far-shore)													
Main Engines	2.43	3.00	5.78	0.22	0.20	0.46	0.20	2.48E-05	0.02	759.80	1.16E-02	0.03	770.08
Tender Support Vessel													
Main Engines	1.09E-02	0.20	0.17	4.66E-03	4.52E-03	2.08E-04	9.72E-04	5.65E-07	7.15E-06	22.60	3.33E-04	1.11E-03	22.94
Main Engines	8.14E-03	0.15	0.12	3.49E-03	3.39E-03	1.56E-04	7.29E-04	4.24E-07	5.36E-06	16.95	2.50E-04	8.29E-04	17.21
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-Array Cable Lay Vessel													
Main Engines	0.57	10.35	6.26	0.63	0.61	7.82E-03	0.06	7.59E-05	2.69E-04	850.51	0.01	0.04	863.22
Installation Support Vessel													
Main Engines	1.52E-02	0.27	0.17	0.02	0.02	2.08E-04	1.57E-03	2.02E-06	7.15E-06	22.60	3.33E-04	1.11E-03	22.94
Main Engines	1.14E-02	0.21	0.12	1.25E-02	1.21E-02	1.56E-04	1.18E-03	1.51E-06	5.36E-06	16.95	2.50E-04	8.29E-04	17.21
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	0.26	6.50	0.54	0.09	0.08	0.20	0.02	1.06E-05	6.79E-03	323.52	4.92E-03	0.01	327.89
Aux. Engine	0.01	0.46	0.11	0.01	0.01	2.73E-04	7.77E-04	1.64E-06	9.40E-06	29.73	1.18E-04	1.45E-03	30.17
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**5.32**	**68.56**	**21.37**	**1.97**	**1.86**	**1.88**	**0.47**	**2.32E-04**	**0.06**	**4,757.45**	**0.07**	**0.22**	**4,823.82**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)\ *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions (cont.)

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Pre-Sweep Dredger/Tug Combination		N/A	480 x 92 x 36 (30)						
Tugboat Main Engines	2			1.31	7,831	Diesel	15,000	15,000	3.18
Tugboat Harbor Engine	1			1.12	979	Diesel			
Tugboat Emergency Engine	1			1.12	737	Diesel			
Dredger Pump Engines	2			1.32	5,000	Diesel			
Dredger Harbor Engine	1			1.21	1,220	Diesel			
Pre-Trenching Barge		N/A	401 x 110 x 25 (18)						
Main Engines	4			1.21	1,332	Diesel	20,000	20,000	3.18
Crane Engine	1			1.12	536	Diesel			
Emergency Engine	1			1.12	361	Diesel			
Pre-Trenching Tug 1		N/A	98 x 31 x 10 (8)						
Main Engines	2			2.07	1,260	Diesel	2,500	2,500	3.18
Aux. Engine	1			2.06	449	Diesel			
Emergency Engine	1			2.04	87	Diesel			
Pre-Trenching Tug 2		N/A	98 x 31 x 10 (8)						
Main Engines	2			2.07	1,260	Diesel	2,500	2,500	3.18
Aux. Engine	1			2.06	449	Diesel			
Emergency Engine	1			2.04	87	Diesel			
Pre-Lay Grapnel Run Vessel		N/A	150 x 36 x 10						
Main Engines	2			2.07	750	Diesel	4,000	4,000	3.18
Aux. Engine	1			2.04	133	Diesel			
Bow Thruster Engine	1			2.04	325	Diesel			
Aux. Engine	1			2.04	133	Diesel			
Export Cable Safety Vessel		N/A	65 x 17 x 5						
Main Engines	2			2.06	660	Diesel	5,000	5,000	3.18
Main Engines	2			2.03	27	Diesel			
Interarray Cable Safety Vessel		N/A	65 x 17 x 5						
Main Engines	2			2.06	660	Diesel	5,000	5,000	3.18
Main Engines	2			2.03	27	Diesel			
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions (cont.)

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Pre-Sweep Dredger/Tug Combination										
Tugboat Main Engines	1	9	0	14	24	336	26%	16%	1,769	66,038
Tugboat Harbor Engine	0	0	0	0	0	0	0%	0%		
Tugboat Emergency Engine	0	0	0	0	0	0	0%	0%		
Dredger Pump Engines	0	0	0	14	24	336	0%	16%		
Dredger Harbor Engine	0	0	0	0	0	0	0%	0%		
Pre-Trenching Barge										
Main Engines	1	15	0	14	24	336	98%	89%	3,931	88,050
Crane Engine	0	0	0	14	24	336	0%	89%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Pre-Trenching Tug 1										
Main Engines	1	15	0	14	24	336	22%	22%	491	11,006
Aux. Engine	1	15	0	14	24	336	22%	22%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Pre-Trenching Tug 2										
Main Engines	1	15	0	14	24	336	22%	22%	491	11,006
Aux. Engine	1	15	0	14	24	336	22%	22%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Pre-Lay Grapnel Run Vessel										
Main Engines	2	9	0	14	24	336	64%	50%	943	17,610
Aux. Engine	2	9	0	14	24	336	64%	50%		
Bow Thruster Engine	0	0	0	14	24	336	0%	50%		
Aux. Engine	0	0	0	14	24	336	0%	50%		
Export Cable Safety Vessel										
Main Engines	3	9	0	106	24	2,544	95%	95%	1,769	166,667
Main Engines	3	9	0	106	24	2,544	95%	95%		
Interarray Cable Safety Vessel										
Main Engines	3	9	0	106	24	2,544	95%	95%	1,769	166,667
Main Engines	3	9	0	106	24	2,544	95%	95%		
TOTALS									**424,654**	**5,313,836**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions (cont.)

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Pre-Sweep Dredger/Tug Combination													
Tugboat Main Engines	0.35	8.89	0.74	0.13	0.12	0.27	3.11E-02	1.45E-05	9.29E-03	442.83	6.74E-03	1.95E-02	448.83
Tugboat Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tugboat Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredger Pump Engines	0.18	5.94	0.47	0.08	0.07	0.18	1.62E-02	9.33E-06	6.28E-03	299.30	3.44E-03	1.25E-02	303.10
Dredger Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Barge													
Main Engines	0.19	13.89	3.27	0.41	0.39	8.22E-03	0.02	4.93E-05	2.83E-04	894.57	0.00	4.37E-02	907.70
Crane Engine	5.72E-02	1.30	0.24	9.67E-02	9.38E-02	8.27E-04	6.61E-03	1.17E-05	2.85E-05	90.00	1.09E-03	4.40E-03	91.34
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Tug 1													
Main Engines	5.83E-02	1.05	0.77	3.07E-02	2.98E-02	9.60E-04	5.34E-03	3.73E-06	3.30E-05	104.46	1.26E-03	5.11E-03	106.01
Aux. Engine	1.04E-02	0.19	0.14	5.48E-03	5.31E-03	1.71E-04	9.51E-04	6.64E-07	5.89E-06	18.61	2.25E-04	9.10E-04	18.89
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Tug 2													
Main Engines	5.83E-02	1.05	0.77	3.07E-02	2.98E-02	9.60E-04	5.34E-03	3.73E-06	3.30E-05	104.46	1.26E-03	5.11E-03	106.01
Aux. Engine	1.04E-02	0.19	0.14	5.48E-03	5.31E-03	1.71E-04	9.51E-04	6.64E-07	5.89E-06	18.61	2.25E-04	9.10E-04	18.89
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Lay Grapnel Run Vessel													
Main Engines	0.08	1.42	1.04	0.04	0.04	1.30E-03	7.22E-03	5.04E-06	4.47E-05	141.26	1.70E-03	6.91E-03	143.36
Aux. Engine	7.28E-03	0.13	0.09	7.37E-03	7.15E-03	1.15E-04	7.39E-04	8.94E-07	3.96E-06	12.52	1.51E-04	6.13E-04	12.71
Bow Thruster Engine	1.78E-02	0.32	0.23	1.80E-02	1.75E-02	2.81E-04	1.81E-03	2.18E-06	9.68E-06	30.61	3.69E-04	1.50E-03	31.06
Aux. Engine	7.28E-03	0.13	0.09	7.37E-03	7.15E-03	1.15E-04	7.39E-04	8.94E-07	3.96E-06	12.52	1.51E-04	6.13E-04	12.71
Export Cable Safety Vessel													
Main Engines	1.00	18.03	13.18	0.53	0.51	0.02	0.09	6.39E-05	5.66E-04	1,790.90	0.02	0.09	1,817.54
Main Engines	0.04	0.76	0.59	0.06	0.06	6.69E-04	4.79E-03	7.79E-06	2.30E-05	72.75	8.78E-04	3.56E-03	73.83
Interarray Cable Safety Vessel													
Main Engines	1.00	18.03	13.18	0.53	0.51	0.02	0.09	6.39E-05	5.66E-04	1,790.90	0.02	0.09	1,817.54
Main Engines	0.04	0.76	0.59	0.06	0.06	6.69E-04	4.79E-03	7.79E-06	2.30E-05	72.75	8.78E-04	3.56E-03	73.83
TOTALS	**63.56**	**724.46**	**342.78**	**23.68**	**22.61**	**15.90**	**5.61**	**2.83E-03**	**0.55**	**59,546.21**	**0.85**	**2.79**	**60,398.58**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb) *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions (cont.)

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Pre-Sweep Dredger/Tug Combination													
Tugboat Main Engines	0.02	0.40	0.03	5.65E-03	5.20E-03	1.21E-02	1.40E-03	6.50E-07	4.17E-04	19.88	3.02E-04	8.77E-04	20.15
Tugboat Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tugboat Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredger Pump Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredger Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Barge													
Main Engines	9.13E-03	0.68	0.16	0.02	0.02	4.04E-04	1.15E-03	2.42E-06	1.39E-05	43.95	1.75E-04	2.15E-03	44.60
Crane Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Tug 1													
Main Engines	2.60E-03	0.05	0.03	1.37E-03	1.33E-03	4.29E-05	2.38E-04	1.66E-07	1.47E-06	4.66	5.63E-05	2.28E-04	4.73
Aux. Engine	4.64E-04	8.36E-03	6.11E-03	2.45E-04	2.37E-04	7.64E-06	4.24E-05	2.97E-08	2.63E-07	0.83	1.00E-05	4.06E-05	0.84
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Tug 2													
Main Engines	2.60E-03	0.05	0.03	1.37E-03	1.33E-03	4.29E-05	2.38E-04	1.66E-07	1.47E-06	4.66	5.63E-05	2.28E-04	4.73
Aux. Engine	4.64E-04	8.36E-03	6.11E-03	2.45E-04	2.37E-04	7.64E-06	4.24E-05	2.97E-08	2.63E-07	0.83	1.00E-05	4.06E-05	0.84
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Lay Grapnel Run Vessel													
Main Engines	5.41E-03	0.10	0.07	2.85E-03	2.77E-03	8.91E-05	4.95E-04	3.46E-07	3.06E-06	9.69	1.17E-04	4.74E-04	9.83
Aux. Engine	4.99E-04	9.01E-03	6.32E-03	5.06E-04	4.91E-04	7.90E-06	5.07E-05	6.13E-08	2.72E-07	0.86	1.04E-05	4.20E-05	0.87
Bow Thruster Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Safety Vessel													
Main Engines	1.06E-02	0.19	0.14	5.59E-03	5.43E-03	1.75E-04	9.71E-04	6.78E-07	6.01E-06	19.01	2.29E-04	9.30E-04	19.29
Main Engines	4.56E-04	8.10E-03	6.25E-03	6.82E-04	6.61E-04	7.10E-06	5.08E-05	8.27E-08	2.44E-07	0.77	9.32E-06	3.78E-05	0.78
Interarray Cable Safety Vessel													
Main Engines	1.06E-02	0.19	0.14	5.59E-03	5.43E-03	1.75E-04	9.71E-04	6.78E-07	6.01E-06	19.01	2.29E-04	9.30E-04	19.29
Main Engines	4.56E-04	8.10E-03	6.25E-03	6.82E-04	6.61E-04	7.10E-06	5.08E-05	8.27E-08	2.44E-07	0.77	9.32E-06	3.78E-05	0.78
TOTALS	**5.32**	**68.56**	**21.37**	**1.97**	**1.86**	**1.88**	**0.47**	**2.32E-04**	**0.06**	**4,757.45**	**0.07**	**0.22**	**4,823.82**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-9. EW 1 Export and Interarray Cable Installation Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 57 wind turbine locations for EW 1.
2. Emissions for the route preparation vessels (pre-lay grapnel run, pre-sweep dredging, and pre-trenching) are based on the total EW 1 cable length of 156 nm (116 nm for interarray cables and 40 nm for export cable).
3. Emissions for the fall pipe vessel assume scour protection will be required for 10% of the total EW 1 cable length of 156 nm (116 nm for interarray cables and 40 nm for export cable route).
4. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   - Charleston-area port to center of OCS lease area: 643 nm (23 nm in SC state waters, 590 nm in non-OCS federal waters, and 30 nm within OCS radius)
   - South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm
   - Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
5. The number of transits for each vessel are based on the following assumptions:
   - 1 round trip to/from port for pre-sweep dregding and pre-trenching vessels.
   - 2 round trips each to/from Charleston, SC for cable spool transport, mid-shore, and far-shore export cable lay vessels
   - 3 round trips to/from Charleston, SC for interarray cable lay vessel
   - 2 round trips to/from port for cable lay support vessels and pre-lay grapnel run vessel.
   - 8 round trips to/from overseas port for the fall pipe vessel (based on volume required to install scour protection for 10% of total cable length).
   - Monthly round trips to/from port for safety vessels.
6. The export cable lay vessels are assumed to operate in the following locations:
   - 38 days in NY state waters (14 days inside OCS radius) for near-shore cable lay barge
   - 20 days in SC state waters, 40 days in NY state waters, and 2 days in federal waters (42 days inside OCS radius) for mid-shore export cable lay vessel
   - 10 days in SC state waters, and 132 days in federal waters (132 days inside OCS radius) for far-shore export cable lay vessel
   - 30 days in SC state waters, and 106 days in federal waters (106 days inside OCS radius) for interarray cable lay vessel
7. Helicopter transits to the export cable lay vessel assume two round trips per week, with a duration of 30 minutes per round trip based on travel from JFK Int'l Airport. One-way distance estimated to average 14 mi along the EW 1 export cable route (varies from 10 to 24 mi, with total mileage distributions of 30% in Kings County, 27% in Queens County, 9% in Nassau County, and 34% inside OCS radius).
8. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
9. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
10. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
11. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
12. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
13. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
14. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Helicopter - Twin-Engine Heavy		N/A							
Main Engines	2			164	1,400	Jet fuel	N/A	N/A	N/A
Export Cable Lay Vessel (Near-shore)		1	388 x 105 x 26 (18)						
Stern Thruster Engines	2			2.09	2,640	Diesel	15,000	15,000	3.18
Bow Thruster Engines	2			2.09	2,500	Diesel			
Main Engines	4			2.07	536	Diesel			
Emergency Engine	1			2.05	94	Diesel			
Export Cable Lay Vessel (Far-shore)		1	492 x 102 x 42 (29)						
Main Engines	6			5.02	4,625	Diesel	20,000	20,000	3.18
Installation Support Vessel 1		1	243 x 56 x 26 (21)						
Main Engines	2			2.09	2,466	Diesel	15,000	15,000	3.18
Main Engines	2			2.09	1,850	Diesel			
Emergency Engine	1			2.07	382	Diesel			
Inter-Array Cable Lay Vessel		1	313 x 71 x 29 (24)						
Main Engines	4			2.09	2,606	Diesel	15,000	15,000	3.18
Installation Support Vessel 2		1	243 x 56 x 26 (21)						
Main Engines	2			2.09	2,466	Diesel	15,000	15,000	3.18
Main Engines	2			2.09	1,850	Diesel			
Emergency Engine	1			2.07	382	Diesel			
Fall Pipe Vessel - Scour protection		1	520 x 118 x 44 (31)						
Main Engines	3			1.31	6,032	Diesel	50,000	10,000	3.18
Aux. Engine	1			1.21	1,609	Diesel			
Emergency Engine	1			1.12	660	Diesel			
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Helicopter - Twin-Engine Heavy										
Main Engines	38	0.5	0	0	0	0	100%	0%	5,980	0
Export Cable Lay Vessel (Near-shore)										
Stern Thruster Engines	1	129	10	44	24	1,296	32%	32%	25,354	254,717
Bow Thruster Engines	1	129	10	44	24	1,296	32%	32%		
Main Engines	1	129	10	44	24	1,296	32%	32%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Export Cable Lay Vessel (Far-shore)										
Main Engines	1	129	10	89	24	2,376	20%	20%	33,805	622,642
Installation Support Vessel 1										
Main Engines	2	9	0	133	24	3,192	46%	46%	3,538	627,358
Main Engines	2	9	0	133	24	3,192	46%	46%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Inter-Array Cable Lay Vessel										
Main Engines	4	129	40	212	24	6,048	38%	38%	101,415	1,188,679
Installation Support Vessel 2										
Main Engines	2	9	0	212	24	5,088	46%	46%	3,538	1,000,000
Main Engines	2	9	0	212	24	5,088	46%	46%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Fall Pipe Vessel - Scour protection										
Main Engines	9	6	0	152	24	3,648	69%	14%	35,377	477,987
Aux. Engine	9	6	0	152	24	3,648	69%	14%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
TOTALS									**224,887**	**5,142,453**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Lay Vessel (Near-shore)													
Stern Thruster Engines	0.82	14.72	8.91	0.89	0.86	1.11E-02	0.08	1.08E-04	3.83E-04	1,210.37	0.02	0.06	1,228.45
Bow Thruster Engines	0.77	13.94	8.43	0.84	0.82	1.05E-02	0.08	1.02E-04	3.63E-04	1,146.18	0.02	0.06	1,163.31
Main Engines	0.27	4.95	3.62	0.14	0.14	4.52E-03	2.51E-02	1.75E-05	1.56E-04	491.66	0.01	2.40E-02	498.97
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Lay Vessel (Far-shore)													
Main Engines	22.42	27.65	53.23	1.99	1.83	4.27	1.85	2.29E-04	0.15	6,997.22	0.11	0.31	7,091.89
Installation Support Vessel 1													
Main Engines	2.70	48.76	29.50	2.95	2.86	0.04	0.28	3.58E-04	1.27E-03	4,008.60	0.06	0.20	4,068.49
Main Engines	2.03	36.57	22.12	2.21	2.15	0.03	0.21	2.68E-04	9.51E-04	3,006.45	0.04	0.15	3,051.37
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-Array Cable Lay Vessel													
Main Engines	8.96	161.68	97.81	9.78	9.49	0.12	0.92	1.19E-03	4.20E-03	13,291.67	0.20	0.65	13,490.26
Installation Support Vessel 2													
Main Engines	4.31	77.72	47.02	4.70	4.56	0.06	0.44	5.70E-04	2.02E-03	6,389.64	0.09	0.31	6,485.11
Main Engines	3.23	58.29	35.26	3.53	3.42	0.04	0.33	4.28E-04	1.52E-03	4,792.23	0.07	0.23	4,863.83
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	3.94	98.76	8.23	1.40	1.29	3.00	0.35	1.61E-04	0.10	4,917.44	0.07	0.22	4,983.97
Aux. Engine	0.09	7.02	1.65	0.21	0.20	4.15E-03	0.01	2.49E-05	1.43E-04	451.90	0.00	2.21E-02	458.53
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**55.33**	**679.45**	**383.39**	**32.35**	**31.20**	**8.39**	**5.13**	**3.90E-03**	**0.29**	**57,567.56**	**0.81**	**2.75**	**58,407.75**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0.03	0.33	7.79E-03	7.60E-03	7.60E-03	0.02	6.57E-04	3.18E-07	6.90E-04	63.08	1.81E-03	2.09E-03	63.75
Export Cable Lay Vessel (Near-shore)													
Stern Thruster Engines	0.08	1.47	0.89	0.09	0.09	1.11E-03	8.38E-03	1.07E-05	3.81E-05	120.48	0.00	5.89E-03	122.28
Bow Thruster Engines	0.08	1.39	0.84	0.08	0.08	1.05E-03	7.94E-03	1.02E-05	3.61E-05	114.09	1.68E-03	5.58E-03	115.79
Main Engines	2.73E-02	0.49	0.36	1.44E-02	1.40E-02	4.50E-04	2.50E-03	1.75E-06	1.55E-05	48.94	5.91E-04	2.39E-03	49.67
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Lay Vessel (Far-shore)													
Main Engines	1.22	1.50	2.89	0.11	0.10	0.23	0.10	1.24E-05	7.97E-03	379.90	5.78E-03	0.02	385.04
Installation Support Vessel 1													
Main Engines	1.52E-02	0.27	0.17	0.02	0.02	2.08E-04	1.57E-03	2.02E-06	7.15E-06	22.60	3.33E-04	1.11E-03	22.94
Main Engines	1.14E-02	0.21	0.12	1.25E-02	1.21E-02	1.56E-04	1.18E-03	1.51E-06	5.36E-06	16.95	2.50E-04	8.29E-04	17.21
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-Array Cable Lay Vessel													
Main Engines	0.76	13.79	8.34	0.83	0.81	1.04E-02	0.08	1.01E-04	3.59E-04	1,134.01	0.02	0.06	1,150.95
Installation Support Vessel 2													
Main Engines	1.52E-02	0.27	0.17	0.02	0.02	2.08E-04	1.57E-03	2.02E-06	7.15E-06	22.60	3.33E-04	1.11E-03	22.94
Main Engines	1.14E-02	0.21	0.12	1.25E-02	1.21E-02	1.56E-04	1.18E-03	1.51E-06	5.36E-06	16.95	2.50E-04	8.29E-04	17.21
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel - Scour protection													
Main Engines	0.29	7.31	0.61	0.10	0.10	0.22	0.03	1.19E-05	7.64E-03	363.96	5.54E-03	0.02	368.88
Aux. Engine	0.01	0.52	0.12	0.02	0.01	3.07E-04	8.74E-04	1.84E-06	1.06E-05	33.45	1.33E-04	1.64E-03	33.94
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**2.63**	**29.99**	**15.68**	**1.38**	**1.32**	**0.50**	**0.24**	**1.65E-04**	**0.02**	**2,514.69**	**0.04**	**0.12**	**2,550.88**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)\ *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions (cont.)

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Pre-Sweep Dredger/Tug Combination		N/A	480 x 92 x 36 (30)						
Tugboat Main Engines	2			1.31	7,831	Diesel	15,000	15,000	3.18
Tugboat Harbor Engine	1			1.12	979	Diesel			
Tugboat Emergency Engine	1			1.12	737	Diesel			
Dredger Pump Engines	2			1.32	5,000	Diesel			
Dredger Harbor Engine	1			1.21	1,220	Diesel			
Pre-Trenching Barge		N/A	401 x 110 x 25 (18)						
Main Engines	4			1.21	1,332	Diesel	20,000	20,000	3.18
Crane Engine	1			1.12	536	Diesel			
Emergency Engine	1			1.12	361	Diesel			
Pre-Trenching Tug 1		N/A	98 x 31 x 10 (8)						
Main Engines	2			2.07	1,260	Diesel	2,500	2,500	3.18
Aux. Engine	1			2.06	449	Diesel			
Emergency Engine	1			2.04	87	Diesel			
Pre-Trenching Tug 2		N/A	98 x 31 x 10 (8)						
Main Engines	2			2.07	1,260	Diesel	2,500	2,500	3.18
Aux. Engine	1			2.06	449	Diesel			
Emergency Engine	1			2.04	87	Diesel			
Pre-Lay Grapnel Run Vessel		N/A	150 x 36 x 10						
Main Engines	2			2.07	750	Diesel	4,000	4,000	3.18
Aux. Engine	1			2.04	133	Diesel			
Bow Thruster Engine	1			2.04	325	Diesel			
Aux. Engine	1			2.04	133	Diesel			
Export Cable Safety Vessel		N/A	65 x 17 x 5						
Main Engines	2			2.06	660	Diesel	5,000	5,000	3.18
Main Engines	2			2.03	27	Diesel			
Interarray Cable Safety Vessel		N/A	65 x 17 x 5						
Main Engines	2			2.06	660	Diesel	5,000	5,000	3.18
Main Engines	2			2.03	27	Diesel			
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions (cont.)

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Pre-Sweep Dredger/Tug Combination										
Tugboat Main Engines	1	9	0	22	24	528	26%	16%	1,769	103,774
Tugboat Harbor Engine	0	0	0	0	0	0	0%	0%		
Tugboat Emergency Engine	0	0	0	0	0	0	0%	0%		
Dredger Pump Engines	0	0	0	22	24	528	0%	16%		
Dredger Harbor Engine	0	0	0	0	0	0	0%	0%		
Pre-Trenching Barge										
Main Engines	1	15	0	22	24	528	98%	89%	3,931	138,365
Crane Engine	0	0	0	22	24	528	0%	89%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Pre-Trenching Tug 1										
Main Engines	1	15	0	22	24	528	22%	22%	491	17,296
Aux. Engine	1	15	0	22	24	528	22%	22%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Pre-Trenching Tug 2										
Main Engines	1	15	0	22	24	528	22%	22%	491	17,296
Aux. Engine	1	15	0	22	24	528	22%	22%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Pre-Lay Grapnel Run Vessel										
Main Engines	2	9	0	22	24	528	64%	50%	943	27,673
Aux. Engine	2	9	0	22	24	528	64%	50%		
Bow Thruster Engine	0	0	0	22	24	528	0%	50%		
Aux. Engine	0	0	0	22	24	528	0%	50%		
Export Cable Safety Vessel										
Main Engines	7	9	0	212	24	5,088	95%	95%	4,127	333,333
Main Engines	7	9	0	212	24	5,088	95%	95%		
Interarray Cable Safety Vessel										
Main Engines	7	9	0	212	24	5,088	95%	95%	4,127	333,333
Main Engines	7	9	0	212	24	5,088	95%	95%		
TOTALS									**224,887**	**5,142,453**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions (cont.)

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Pre-Sweep Dredger/Tug Combination													
Tugboat Main Engines	0.56	13.98	1.16	0.20	0.18	0.42	0.05	2.27E-05	0.01	695.88	1.06E-02	0.03	705.30
Tugboat Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tugboat Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredger Pump Engines	0.28	9.33	0.74	0.13	0.12	0.29	0.03	1.47E-05	9.87E-03	470.32	5.41E-03	0.02	476.30
Dredger Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Barge													
Main Engines	0.29	21.83	5.13	0.64	0.62	1.29E-02	0.04	7.75E-05	4.45E-04	1,405.75	0.01	0.07	1,426.38
Crane Engine	0.09	2.04	0.37	0.15	0.15	1.30E-03	1.04E-02	1.84E-05	4.47E-05	141.42	0.00	6.92E-03	143.53
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Tug 1													
Main Engines	0.09	1.65	1.21	0.05	4.69E-02	1.51E-03	8.38E-03	5.86E-06	5.19E-05	164.15	0.00	8.03E-03	166.59
Aux. Engine	1.63E-02	0.29	0.22	8.61E-03	8.35E-03	2.69E-04	1.49E-03	1.04E-06	9.25E-06	29.25	3.53E-04	1.43E-03	29.68
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Tug 2													
Main Engines	0.09	1.65	1.21	0.05	0.05	1.51E-03	8.38E-03	5.86E-06	5.19E-05	164.15	0.00	8.03E-03	166.59
Aux. Engine	1.63E-02	0.29	0.22	8.61E-03	8.35E-03	2.69E-04	1.49E-03	1.04E-06	9.25E-06	29.25	3.53E-04	1.43E-03	29.68
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Lay Grapnel Run Vessel													
Main Engines	0.12	2.23	1.63	0.07	0.06	2.04E-03	1.13E-02	7.92E-06	7.02E-05	221.98	0.00	1.09E-02	225.28
Aux. Engine	1.14E-02	0.21	0.14	1.16E-02	1.12E-02	1.81E-04	1.16E-03	1.40E-06	6.23E-06	19.68	2.38E-04	9.63E-04	19.97
Bow Thruster Engine	2.80E-02	0.50	0.35	0.03	0.03	4.42E-04	2.84E-03	3.43E-06	1.52E-05	48.09	5.80E-04	2.35E-03	48.81
Aux. Engine	1.14E-02	0.21	0.14	1.16E-02	1.12E-02	1.81E-04	1.16E-03	1.40E-06	6.23E-06	19.68	2.38E-04	9.63E-04	19.97
Export Cable Safety Vessel													
Main Engines	2.00	36.06	26.36	1.05	1.02	0.03	0.18	1.28E-04	1.13E-03	3,581.80	0.04	0.18	3,635.08
Main Engines	0.09	1.53	1.18	0.13	0.12	1.34E-03	9.58E-03	1.56E-05	4.60E-05	145.50	0.00	7.12E-03	147.66
Interarray Cable Safety Vessel													
Main Engines	2.00	36.06	26.36	1.05	1.02	0.03	0.18	1.28E-04	1.13E-03	3,581.80	0.04	0.18	3,635.08
Main Engines	0.09	1.53	1.18	0.13	0.12	1.34E-03	9.58E-03	1.56E-05	4.60E-05	145.50	0.00	7.12E-03	147.66
TOTALS	**55.33**	**679.45**	**383.39**	**32.35**	**31.20**	**8.39**	**5.13**	**3.90E-03**	**0.29**	**57,567.56**	**0.81**	**2.75**	**58,407.75**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions (cont.)

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Pre-Sweep Dredger/Tug Combination													
Tugboat Main Engines	0.02	0.40	0.03	5.65E-03	5.20E-03	1.21E-02	1.40E-03	6.50E-07	4.17E-04	19.88	3.02E-04	8.77E-04	20.15
Tugboat Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tugboat Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredger Pump Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredger Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Barge													
Main Engines	0.01	0.68	0.16	0.02	0.02	4.04E-04	1.15E-03	2.42E-06	1.39E-05	43.95	1.75E-04	2.15E-03	44.60
Crane Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Tug 1													
Main Engines	2.60E-03	0.05	0.03	1.37E-03	1.33E-03	4.29E-05	2.38E-04	1.66E-07	1.47E-06	4.66	5.63E-05	2.28E-04	4.73
Aux. Engine	4.64E-04	8.36E-03	6.11E-03	2.45E-04	2.37E-04	7.64E-06	4.24E-05	2.97E-08	2.63E-07	0.83	1.00E-05	4.06E-05	0.84
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Trenching Tug 2													
Main Engines	2.60E-03	0.05	0.03	1.37E-03	1.33E-03	4.29E-05	2.38E-04	1.66E-07	1.47E-06	4.66	5.63E-05	2.28E-04	4.73
Aux. Engine	4.64E-04	8.36E-03	6.11E-03	2.45E-04	2.37E-04	7.64E-06	4.24E-05	2.97E-08	2.63E-07	0.83	1.00E-05	4.06E-05	0.84
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-Lay Grapnel Run Vessel													
Main Engines	5.41E-03	0.10	0.07	2.85E-03	2.77E-03	8.91E-05	4.95E-04	3.46E-07	3.06E-06	9.69	1.17E-04	4.74E-04	9.83
Aux. Engine	4.99E-04	9.01E-03	6.32E-03	5.06E-04	4.91E-04	7.90E-06	5.07E-05	6.13E-08	2.72E-07	0.86	1.04E-05	4.20E-05	0.87
Bow Thruster Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Safety Vessel													
Main Engines	2.47E-02	0.45	0.33	1.31E-02	1.27E-02	4.08E-04	2.27E-03	1.58E-06	1.40E-05	44.35	5.35E-04	2.17E-03	45.01
Main Engines	1.06E-03	0.02	1.46E-02	1.59E-03	1.54E-03	1.66E-05	1.19E-04	1.93E-07	5.70E-07	1.80	2.17E-05	8.81E-05	1.83
Interarray Cable Safety Vessel													
Main Engines	2.47E-02	0.45	0.33	1.31E-02	1.27E-02	4.08E-04	2.27E-03	1.58E-06	1.40E-05	44.35	5.35E-04	2.17E-03	45.01
Main Engines	1.06E-03	0.02	1.46E-02	1.59E-03	1.54E-03	1.66E-05	1.19E-04	1.93E-07	5.70E-07	1.80	2.17E-05	8.81E-05	1.83
TOTALS	**2.63**	**29.99**	**15.68**	**1.38**	**1.32**	**0.50**	**0.24**	**1.65E-04**	**0.02**	**2,514.69**	**0.04**	**0.12**	**2,550.88**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-10. EW 2 Export and Interarray Cable Installation Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 90 wind turbine locations for EW 2.
2. Operating days for export cable vessels are scaled down from the EW 1 (Gowanus) cable route (40 nm), proportionate to the EW 2 (Oceanside) export cable length (26 nm).
3. Operating days for route preparation vessels (pre-lay grapnel run, pre-sweep dredging, and pre-trenching) are scaled up from the total EW 1 cable length (156 nm), proportionate to the total EW 2 cable length of 170 nm (144 nm for interarray cables and 26 nm for export cable).
4. Operating days for the fall pipe vessel assume scour protection will be required for 10% of the total EW 2 cable length of 170 nm, and are scaled up from the total EW 1 cable length of 156 nm.
5. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   - Charleston-area port to center of OCS lease area: 643 nm (23 nm in SC state waters, 590 nm in non-OCS federal waters, and 30 nm within OCS radius)
   - South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm
   - Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
6. The number of transits for each vessel are based on the following assumptions:
   - 1 round trip to/from port for pre-sweep dregding and pre-trenching vessels.
   - 1 round trip each to/from Charleston, SC for near-shore and far-shore export cable lay vessels
   - 4 round trips to/from Charleston, SC for interarray cable lay vessel
   - 2 round trips to/from port for cable lay support vessels and pre-lay grapnel run vessel.
   - 9 round trips to/from overseas port for the fall pipe vessel (based on volume required to install scour protection for 10% of total cable length).
   - Monthly round trips to/from port for safety vessels.
7. The export cable lay vessels are assumed to operate in the following locations:
   - 10 days in SC state waters, and 44 days in NY state waters (44 days inside OCS radius) for near-shore export cable lay vessel
   - 10 days in SC state waters, and 89 in federal waters (89 days inside OCS radius) for far-shore export cable lay vessel
   - 40 days in SC state waters, and 212 days in federal waters (212 days inside OCS radius) for interarray cable lay vessel
8. Helicopter transits to the export cable lay vessel assume two round trips per week, with a duration of 30 minutes per round trip based on travel from JFK Int'l Airport. One-way distance estimated to average 20 mi along the EW 2 export cable route (varies from 8 to 32 mi, with total mileage distributions of 6% in Queens County, 41% in Nassau County, and 53% inside OCS radius).
9. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
10. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
11. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
12. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
13. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
14. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
15. CO2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-11. EW 1 Export Cable Landfall Marine Construction Emissions

LANDFALL MARINE INSTALLATION EQUIPMENT FOR EW 1

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Channel Area Dredger/Tug Combination		N/A	480 x 92 x 36 (30)						
-Tugboat Main Engines	2			1.31	7,831	Diesel	15,000	15,000	3.18
-Tugboat Harbor Generator	1			1.12	979	Diesel			
-Tugboat Emergency Generator	1			1.12	737	Diesel			
-Dredger Pump Engines	2			1.32	5,000	Diesel			
-Dredger Harbor Generator	1			1.21	1,220	Diesel			
Pier Area Dredger/Tug Combination		N/A	480 x 92 x 36 (30)						
-Tugboat Main Engines	2			1.31	7,831	Diesel	15,000	15,000	3.18
-Tugboat Harbor Generator	1			1.12	979	Diesel			
-Tugboat Emergency Generator	1			1.12	737	Diesel			
-Dredger Pump Engines	2			1.32	5,000	Diesel			
-Dredger Harbor Generator	1			1.21	1,220	Diesel			
Tug for O&M Base Pilings		N/A	98 x 31 x 10 (8)						
-Main Engines	2			1.21	1,260	Diesel	1,500	1,500	3.18
-Aux. Generator	1			1.12	449	Diesel			
-Emergency Generator	2			1.12	87	Diesel			
O&M Base Piling Barge		2	400 x 105 x 25						
-Station-keeping Engine	1			1.12	200	Diesel	0	1,000	3.18
- Piling Rig Engine	1			1.12	800	Diesel			
Tug for Cable Landfall and Bulkhead		N/A	98 x 31 x 10 (8)						
-Main Engines	2			1.21	1,260	Diesel	1,500	1,500	3.18
-Aux. Generator	1			1.12	449	Diesel			
-Emergency Generator	2			1.12	87	Diesel			
Cable Landfall and Bulkhead Barge		2	400 x 105 x 25						
-Station-keeping Engine	1			1.12	200	Diesel	0	1,000	3.18
- Piling Rig Engine	1			1.12	800	Diesel			

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-11. EW 1 Export Cable Landfall Marine Construction Emissions

LANDFALL MARINE INSTALLATION EQUIPMENT FOR EW 1

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Channel Area Dredger/Tug Combination										
-Tugboat Main Engines	1	3	0	122	24	2,928	26%	16%	590	575,472
-Tugboat Harbor Generator	0	0	0	0	0	0	0%	0%		
-Tugboat Emergency Generator	0	0	0	0	0	0	0%	0%		
-Dredger Pump Engines	0	0	0	122	24	2,928	0%	16%		
-Dredger Harbor Generator	0	0	0	0	0	0	0%	0%		
Pier Area Dredger/Tug Combination										
-Tugboat Main Engines	1	3	0	62	24	1,488	26%	16%	590	292,453
-Tugboat Harbor Generator	0	0	0	0	0	0	0%	0%		
-Tugboat Emergency Generator	0	0	0	0	0	0	0%	0%		
-Dredger Pump Engines	0	0	0	62	24	1,488	0%	16%		
-Dredger Harbor Generator	0	0	0	0	0	0	0%	0%		
Tug for O&M Base Pilings										
-Main Engines	0	0	0	90	4	360	44%	79%	0	42,453
-Aux. Generator	0	0	0	90	4	360	44%	79%		
-Emergency Generator	0	0	0	0	0	0	0%	0%		
O&M Base Piling Barge										
-Station-keeping Engine	0	0	0	180	12	2,160	0%	112%	0	56,604
- Piling Rig Engine	0	0	0	90	8	720	0%	112%	0	
Tug for Cable Landfall and Bulkhead										
-Main Engines	0	0	0	240	4	960	44%	79%	0	113,208
-Aux. Generator	0	0	0	240	4	960	44%	79%		
-Emergency Generator	0	0	0	0	0	0	0%	0%		
Cable Landfall and Bulkhead Barge										
-Station-keeping Engine	0	0	0	210	5	1,050	0%	85%	0	66,038
- Piling Rig Engine	0	0	0	210	8	1,680	0%	85%	0	
								TOTALS	**1,179**	**966,981**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-11. EW 1 Export Cable Landfall Marine Construction Emissions

LANDFALL MARINE INSTALLATION EQUIPMENT FOR EW 1	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_x tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Channel Area Dredger/Tug Combination													
-Tugboat Main Engines	3.09	77.50	6.46	1.10	1.01	2.35	0.27	1.26E-04	0.08	3,858.98	0.06	0.17	3,911.19
-Tugboat Harbor Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Tugboat Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Dredger Pump Engines	1.58	51.74	4.12	0.71	0.65	1.59	0.14	8.13E-05	0.05	2,608.14	0.03	0.11	2,641.29
-Dredger Harbor Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Pier Area Dredger/Tug Combination													
-Tugboat Main Engines	1.57	39.39	3.28	0.56	0.51	1.20	0.14	6.41E-05	0.04	1,961.12	2.98E-02	0.09	1,987.66
-Tugboat Harbor Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Tugboat Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Dredger Pump Engines	0.80	26.29	2.10	0.36	0.33	0.81	0.07	4.13E-05	0.03	1,325.45	1.52E-02	0.06	1,342.30
-Dredger Harbor Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug for O&M Base Pilings													
-Main Engines	0.08	6.26	1.47	0.18	0.18	3.70E-03	1.05E-02	2.22E-05	1.27E-04	402.91	1.60E-03	0.02	408.82
-Aux. Generator	0.05	1.04	0.19	0.08	0.07	6.60E-04	5.27E-03	9.35E-06	2.27E-05	71.79	8.66E-04	3.51E-03	72.86
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M Base Piling Barge													
-Station-keeping Engine	0.17	3.91	0.72	0.29	0.28	2.49E-03	0.02	3.53E-05	8.58E-05	271.26	3.27E-03	1.33E-02	275.29
- Piling Rig Engine	0.23	5.22	0.96	0.39	0.38	3.32E-03	0.03	4.71E-05	1.14E-04	361.68	4.36E-03	0.02	367.06
Tug for Cable Landfall and Bulkhead													
-Main Engines	0.22	16.68	3.92	0.49	0.47	9.88E-03	0.03	5.92E-05	3.40E-04	1,074.42	4.27E-03	0.05	1,090.18
-Aux. Generator	0.12	2.76	0.51	0.21	0.20	1.76E-03	1.41E-02	2.49E-05	6.06E-05	191.45	2.31E-03	9.36E-03	194.30
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Cable Landfall and Bulkhead Barge													
-Station-keeping Engine	0.06	1.44	0.26	0.11	0.10	9.17E-04	7.33E-03	1.30E-05	3.16E-05	99.79	1.20E-03	4.88E-03	101.27
- Piling Rig Engine	0.41	9.21	1.69	0.69	0.67	5.87E-03	0.05	8.32E-05	2.02E-04	638.64	7.71E-03	0.03	648.14
	8.39	**241.43**	**25.68**	**5.15**	**4.86**	**5.98**	**0.78**	**6.07E-04**	**0.21**	**12,865.64**	**0.16**	**0.57**	**13,040.37**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-11. EW 1 Export Cable Landfall Marine Construction Emissions

LANDFALL MARINE INSTALLATION EQUIPMENT FOR EW 1	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Channel Area Dredger/Tug Combination													
-Tugboat Main Engines	5.31E-03	0.13	1.11E-02	1.88E-03	1.73E-03	4.04E-03	4.65E-04	2.17E-07	1.39E-04	6.63	1.01E-04	2.92E-04	6.72
-Tugboat Harbor Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Tugboat Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Dredger Pump Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
-Dredger Harbor Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Pier Area Dredger/Tug Combination													
-Tugboat Main Engines	5.31E-03	0.13	1.11E-02	1.88E-03	1.73E-03	4.04E-03	4.65E-04	2.17E-07	1.39E-04	6.63	1.01E-04	2.92E-04	6.72
-Tugboat Harbor Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Tugboat Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Dredger Pump Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
-Dredger Harbor Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug for O&M Base Pilings													
-Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
-Aux. Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M Base Piling Barge													
-Station-keeping Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
- Piling Rig Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug for Cable Landfall and Bulkhead													
-Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
-Aux. Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Cable Landfall and Bulkhead Barge													
-Station-keeping Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
- Piling Rig Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.06E-02	**0.27**	**0.02**	**3.77E-03**	**3.46E-03**	**8.08E-03**	**9.30E-04**	**4.33E-07**	**2.78E-04**	**13.25**	**2.02E-04**	**5.85E-04**	**13.43**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)\ *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-11. EW 1 Export Cable Landfall Marine Construction Emissions

Notes:

1. Non-transit activity durations were estimated based on the number of days of operation provided by the project.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   Overseas port to South Brooklyn Marine Terminal: 13.5 nm (only includes portion of transit within the state seaward boundary)
3. The number of transits for each vessel are based on the following assumptions:
   One round trip to/from overseas port for each dredger.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
6. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
8. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
9. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
10. CO2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-12. EW 2 Export Cable Landfall Marine Construction Emissions

LANDFALL MARINE INSTALLATION EQUIPMENT FOR EW 2

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Tug for Cofferdam Barge		N/A	98 x 31 x 10 (8)						
-Main Engines	2			1.21	1,260	Diesel	5,000	5,000	3.18
-Aux. Generator	1			1.12	449	Diesel			
-Emergency Generator	2			1.12	87	Diesel			
Cofferdam Barge		2	400 x 105 x 25						
-Station-keeping Engine	1			1.12	200	Diesel	0	2,000	3.18
- Piling Rig Engine	1			1.12	800	Diesel			
Tug for Existing Equipment Removal		N/A	98 x 31 x 10 (8)						
-Main Engines	2			1.21	1,260	Diesel	5,000	5,000	3.18
-Aux. Generator	1			1.12	449	Diesel			
-Emergency Generator	2			1.12	87	Diesel			
Crane Barge for Existing Equipment Removal		2	400 x 105 x 25						
-Station-keeping Engine	1			1.12	200	Diesel	0	2,000	3.18
- Crane Engine	1			1.12	800	Diesel			
Tug for Cable Bridge		N/A	98 x 31 x 10 (8)						
-Main Engines	2			1.21	1,260	Diesel	5,000	5,000	3.18
-Aux. Generator	1			1.12	449	Diesel			
-Emergency Generator	2			1.12	87	Diesel			
Crane Barge for Cable Bridge		2	400 x 105 x 25						
-Station-keeping Engine	1			1.12	200	Diesel	0	2,000	3.18
- Crane Engine	1			1.12	800	Diesel			
Tug for Bulkhead Installation		N/A	98 x 31 x 10 (8)						
-Main Engines	2			1.21	1,260	Diesel	5,000	5,000	3.18
-Aux. Generator	1			1.12	449	Diesel			
-Emergency Generator	2			1.12	87	Diesel			
Barge for Bulkhead Installation		2	400 x 105 x 25						
-Station-keeping Engine	1			1.12	200	Diesel	0	2,000	3.18
- Piling Rig Engine	1			1.12	800	Diesel			

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-12. EW 2 Export Cable Landfall Marine Construction Emissions

LANDFALL MARINE INSTALLATION EQUIPMENT FOR EW 2

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit otal Operatin Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Tug for Cofferdam Barge										
-Main Engines	4	9	0	120	24	2,880	44%	44%	2,358	188,679
-Aux. Generator	4	9	0	120	24	2,880	44%	44%		
-Emergency Generator	0	0	0	0	0	0	0%	0%		
Cofferdam Barge										
-Station-keeping Engine	1	9	0	120	24	2,880	0%	52%	0	75,472
- Piling Rig Engine	1	9	0	120	24	2,880	0%	52%		
Tug for Existing Equipment Removal										
-Main Engines	4	9	0	120	24	2,880	44%	44%	2,358	188,679
-Aux. Generator	4	9	0	120	24	2,880	44%	44%		
-Emergency Generator	0	0	0	0	0	0	0%	0%		
Crane Barge for Existing Equipment Removal										
-Station-keeping Engine	1	9	0	120	24	2,880	0%	52%	0	75,472
- Crane Engine	1	9	0	120	24	2,880	0%	52%		
Tug for Cable Bridge										
-Main Engines	4	9	0	120	24	2,880	44%	44%	2,358	188,679
-Aux. Generator	4	9	0	120	24	2,880	44%	44%		
-Emergency Generator	0	0	0	0	0	0	0%	0%		
Crane Barge for Cable Bridge										
-Station-keeping Engine	1	9	0	120	24	2,880	0%	52%	0	75,472
- Crane Engine	1	9	0	120	24	2,880	0%	52%		
Tug for Bulkhead Installation										
-Main Engines	4	9	0	120	24	2,880	44%	44%	2,358	188,679
-Aux. Generator	4	9	0	120	24	2,880	44%	44%		
-Emergency Generator	0	0	0	0	0	0	0%	0%		
Barge for Bulkhead Installation										
-Station-keeping Engine	1	9	0	120	24	2,880	0%	52%	0	75,472
- Piling Rig Engine	1	9	0	120	24	2,880	0%	52%		
								TOTALS	**9,434**	**1,056,604**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-12. EW 2 Export Cable Landfall Marine Construction Emissions

LANDFALL MARINE INSTALLATION EQUIPMENT FOR EW 2	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_x tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Tug for Cofferdam Barge													
-Main Engines	0.37	27.80	6.54	0.81	0.79	0.02	0.05	9.87E-05	5.66E-04	1,790.70	7.12E-03	0.09	1,816.97
-Aux. Generator	0.20	4.60	0.85	0.34	0.33	2.93E-03	0.02	4.16E-05	1.01E-04	319.09	3.85E-03	0.02	323.83
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Cofferdam Barge													
-Station-keeping Engine	0.11	2.43	0.45	0.18	0.18	1.55E-03	1.24E-02	2.20E-05	5.34E-05	168.78	2.04E-03	8.25E-03	171.29
- Piling Rig Engine	0.43	9.74	1.79	0.73	0.70	6.21E-03	0.05	8.79E-05	2.14E-04	675.13	8.15E-03	0.03	685.17
Tug for Existing Equipment Removal													
-Main Engines	0.37	27.80	6.54	0.81	0.79	0.02	0.05	9.87E-05	5.66E-04	1,790.70	7.12E-03	0.09	1,816.97
-Aux. Generator	0.20	4.60	0.85	0.34	0.33	2.93E-03	0.02	4.16E-05	1.01E-04	319.09	3.85E-03	0.02	323.83
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Crane Barge for Existing Equipment Removal													
-Station-keeping Engine	0.11	2.43	0.45	0.18	0.18	1.55E-03	1.24E-02	2.20E-05	5.34E-05	168.78	2.04E-03	8.25E-03	171.29
- Crane Engine	0.43	9.74	1.79	0.73	0.70	6.21E-03	0.05	8.79E-05	2.14E-04	675.13	8.15E-03	0.03	685.17
Tug for Cable Bridge													
-Main Engines	0.37	27.80	6.54	0.81	0.79	0.02	0.05	9.87E-05	5.66E-04	1,790.70	7.12E-03	0.09	1,816.97
-Aux. Generator	0.20	4.60	0.85	0.34	0.33	2.93E-03	0.02	4.16E-05	1.01E-04	319.09	3.85E-03	0.02	323.83
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Crane Barge for Cable Bridge													
-Station-keeping Engine	0.11	2.43	0.45	0.18	0.18	1.55E-03	1.24E-02	2.20E-05	5.34E-05	168.78	2.04E-03	8.25E-03	171.29
- Crane Engine	0.43	9.74	1.79	0.73	0.70	6.21E-03	0.05	8.79E-05	2.14E-04	675.13	8.15E-03	0.03	685.17
Tug for Bulkhead Installation													
-Main Engines	0.37	27.80	6.54	0.81	0.79	0.02	0.05	9.87E-05	5.66E-04	1,790.70	7.12E-03	0.09	1,816.97
-Aux. Generator	0.20	4.60	0.85	0.34	0.33	2.93E-03	0.02	4.16E-05	1.01E-04	319.09	3.85E-03	0.02	323.83
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Barge for Bulkhead Installation													
-Station-keeping Engine	0.11	2.43	0.45	0.18	0.18	1.55E-03	1.24E-02	2.20E-05	5.34E-05	168.78	2.04E-03	8.25E-03	171.29
- Piling Rig Engine	0.43	9.74	1.79	0.73	0.70	6.21E-03	0.05	8.79E-05	2.14E-04	675.13	8.15E-03	0.03	685.17
	4.44	**178.31**	**38.47**	**8.26**	**8.01**	**0.11**	**0.53**	**1.00E-03**	**3.74E-03**	**11,814.81**	**0.08**	**0.58**	**11,989.11**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-12. EW 2 Export Cable Landfall Marine Construction Emissions

LANDFALL MARINE INSTALLATION EQUIPMENT FOR EW 2	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_x tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Tug for Cofferdam Barge													
-Main Engines	4.65E-03	0.35	0.08	1.02E-02	9.87E-03	2.06E-04	5.85E-04	1.23E-06	7.08E-06	22.38	8.89E-05	1.09E-03	22.71
-Aux. Generator	2.53E-03	0.06	1.06E-02	4.29E-03	4.16E-03	3.67E-05	2.93E-04	5.20E-07	1.26E-06	3.99	4.81E-05	1.95E-04	4.05
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Cofferdam Barge													
-Station-keeping Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
- Piling Rig Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug for Existing Equipment Removal													
-Main Engines	4.65E-03	0.35	0.08	1.02E-02	9.87E-03	2.06E-04	5.85E-04	1.23E-06	7.08E-06	22.38	8.89E-05	1.09E-03	22.71
-Aux. Generator	2.53E-03	0.06	1.06E-02	4.29E-03	4.16E-03	3.67E-05	2.93E-04	5.20E-07	1.26E-06	3.99	4.81E-05	1.95E-04	4.05
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Crane Barge for Existing Equipment Removal													
-Station-keeping Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
- Crane Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug for Cable Bridge													
-Main Engines	4.65E-03	0.35	0.08	1.02E-02	9.87E-03	2.06E-04	5.85E-04	1.23E-06	7.08E-06	22.38	8.89E-05	1.09E-03	22.71
-Aux. Generator	2.53E-03	0.06	1.06E-02	4.29E-03	4.16E-03	3.67E-05	2.93E-04	5.20E-07	1.26E-06	3.99	4.81E-05	1.95E-04	4.05
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Crane Barge for Cable Bridge													
-Station-keeping Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
- Crane Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug for Bulkhead Installation													
-Main Engines	4.65E-03	0.35	0.08	1.02E-02	9.87E-03	2.06E-04	5.85E-04	1.23E-06	7.08E-06	22.38	8.89E-05	1.09E-03	22.71
-Aux. Generator	2.53E-03	0.06	1.06E-02	4.29E-03	4.16E-03	3.67E-05	2.93E-04	5.20E-07	1.26E-06	3.99	4.81E-05	1.95E-04	4.05
-Emergency Generator	0	0	0	0	0	0	0	0	0	0	0	0	0
Barge for Bulkhead Installation													
-Station-keeping Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
- Piling Rig Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.03	**1.62**	**0.37**	**0.06**	**0.06**	**9.70E-04**	**3.51E-03**	**7.02E-06**	**3.34E-05**	**105.49**	**5.48E-04**	**5.16E-03**	**107.04**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)\ *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-12. EW 2 Export Cable Landfall Marine Construction Emissions

Notes:

1. Non-transit activity durations were estimated based on the number of days of operation provided by the project.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   South Brooklyn Marine Terminal to EW 2 (Oceanside) landfall site: 27 nm (Kings: 7.8 nm; Queens: 3 nm; Nassau: 16.2 nm)
3. The number of transits for each vessel are based on the following assumptions:
   One round trip to/from SBMT for each barge.
   Monthly round trips to/from SBMT for each tug.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
6. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
8. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
9. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
10. CO2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-13. EW 1 Wind Turbine Installation Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Helicopter - Twin-Engine Heavy		N/A							
Main Engines	2			164	1,400	Jet fuel	N/A	N/A	N/A
Main Installation Vessel		3	469 x 273 x 36 (25)						
Main Engines	6			5.02	6,032	Diesel	52,000	11,000	3.18
WTG Installation Generator									
	1	N/A	N/A	1.21	1,609	Diesel	0	6,150	3.18
WTG Commissioning Generators									
	3	N/A	N/A	257	201	Diesel	2,112	2,112	3.18
Tug 1 for WTG Blades/Nacelles (from SBMT)		N/A	146 x 46 x 25 (21)						
Main Engines	2			2.10	5,440	Diesel	19,000	6,000	3.18
Harbor Engine	1			2.07	456	Diesel			
Emergency Engine	1			2.05	168	Diesel			
Tug 2 for WTG Blades/Nacelles (from SBMT)		N/A	146 x 46 x 25 (21)						
Main Engines	2			2.10	5,440	Diesel	19,000	6,000	3.18
Harbor Engine	1			2.07	456	Diesel			
Emergency Engine	1			2.05	168	Diesel			
Cargo Barge 1 (WTG Blades/Nacelles/Towers from SBMT)		N/A	400 x 105 x 25						
							0	0	N/A
Cargo Barge 2 (WTG Blades/Nacelles/Towers from SBMT)		N/A	400 x 105 x 25						
							0	0	N/A
Tug 3 for WTG Towers (Albany to SBMT)		N/A	127 x 36 x 19 (17)						
Main Engines	2			2.08	3,600	Diesel	10,000	0	3.18
Aux. Engines	2			2.06	95	Diesel			
Tug 4 for WTG Towers (Albany to SBMT)		N/A	127 x 36 x 19 (17)						
Main Engines	2			2.08	3,600	Diesel	10,000	0	3.18
Aux. Engines	2			2.06	95	Diesel			
Cargo Barge 3 (WTG Towers Albany to SBMT)		N/A	400 x 105 x 25						
							0	0	N/A
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-13. EW 1 Wind Turbine Installation Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Helicopter - Twin-Engine Heavy										
Main Engines	60	0.5	0	0	0	0	100%	0%	9,442	0
Main Installation Vessel										
Main Engines	1	6	0	251	24	6,024	39%	8%	4,088	868,239
WTG Installation Generator										
	0	0	0	22	24	528	0%	100%	0	42,547
WTG Commissioning Generators										
	0	0	0	57	24	1,368	0%	95%	0	37,857
Tug 1 for WTG Blades/Nacelles (from SBMT)										
Main Engines	29	15	0	251	24	6,024	46%	14%	108,294	473,585
Harbor Engine	0	0	0	0	0	0	0%	0%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Tug 2 for WTG Blades/Nacelles (from SBMT)										
Main Engines	29	15	0	251	24	6,024	46%	14%	108,294	473,585
Harbor Engine	0	0	0	0	0	0	0%	0%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Cargo Barge 1 (WTG Blades/Nacelles/Towers from SBMT)										
	29	15	0	251	24	6,024	N/A	N/A	N/A	N/A
Cargo Barge 2 (WTG Blades/Nacelles/Towers from SBMT)										
	29	15	0	251	24	6,024	N/A	N/A	N/A	N/A
Tug 3 for WTG Towers (Albany to SBMT)										
Main Engines	19	45	0	0	24	0	35%	0%	112,028	0
Aux. Engines	19	45	0	0	24	0	35%	0%		
Tug 4 for WTG Towers (Albany to SBMT)										
Main Engines	19	45	0	0	24	0	35%	0%	112,028	0
Aux. Engines	19	45	0	0	24	0	35%	0%		
Cargo Barge 3 (WTG Towers Albany to SBMT)										
	19	45	0	0	24	0	N/A	N/A	N/A	N/A
TOTALS									**454,175**	**1,895,813**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-13. EW 1 Wind Turbine Installation Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Main Installation Vessel													
Main Engines	31.27	38.55	74.23	2.77	2.55	5.95	2.58	3.19E-04	0.20	9,757.24	0.15	0.43	9,889.25
WTG Installation Generator													
	0.07	5.51	1.30	0.16	0.16	3.26E-03	0.01	1.96E-05	1.12E-04	354.91	0.00	1.74E-02	360.12
WTG Commissioning Generators													
	0.13	0.26	2.27	1.29E-02	1.26E-02	9.71E-04	9.98E-03	1.97E-06	3.34E-05	105.54	4.28E-03	8.56E-04	105.91
Tug 1 for WTG Blades/Nacelles (from SBMT)													
Main Engines	4.02	72.56	38.97	3.90	3.78	0.05	0.40	4.72E-04	1.67E-03	5,295.57	0.08	0.26	5,374.69
Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 2 for WTG Blades/Nacelles (from SBMT)													
Main Engines	4.02	72.56	38.97	3.90	3.78	0.05	0.40	4.72E-04	1.67E-03	5,295.57	0.08	0.26	5,374.69
Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Cargo Barge 1 (WTG Blades/Nacelles/Towers from SBMT)													
Cargo Barge 2 (WTG Blades/Nacelles/Towers from SBMT)													
Tug 3 for WTG Towers (Albany to SBMT)													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 4 for WTG Towers (Albany to SBMT)													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Cargo Barge 3 (WTG Towers Albany to SBMT)													
TOTALS	**39.51**	**189.44**	**155.73**	**10.74**	**10.28**	**6.05**	**3.41**	**1.29E-03**	**0.21**	**20,808.83**	**0.31**	**0.97**	**21,104.66**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-13. EW 1 Wind Turbine Installation Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0.04	0.52	1.23E-02	1.20E-02	1.20E-02	0.03	1.04E-03	5.02E-07	1.09E-03	99.61	2.85E-03	3.30E-03	100.66
Main Installation Vessel													
Main Engines	0.15	0.18	0.35	1.31E-02	1.20E-02	0.03	1.21E-02	1.50E-06	9.64E-04	45.94	6.99E-04	2.03E-03	46.56
WTG Installation Generator													
	0	0	0	0	0	0	0	0	0	0	0	0	0
WTG Commissioning Generators													
	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 1 for WTG Blades/Nacelles (from SBMT)													
Main Engines	0.92	16.59	8.91	0.89	0.86	1.11E-02	0.09	1.08E-04	3.83E-04	1,210.93	0.02	0.06	1,229.02
Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 2 for WTG Blades/Nacelles (from SBMT)													
Main Engines	0.92	16.59	8.91	0.89	0.86	1.11E-02	0.09	1.08E-04	3.83E-04	1,210.93	0.02	0.06	1,229.02
Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Cargo Barge 1 (WTG Blades/Nacelles/Towers from SBMT)													
Cargo Barge 2 (WTG Blades/Nacelles/Towers from SBMT)													
Tug 3 for WTG Towers (Albany to SBMT)													
Main Engines	0.74	13.31	8.98	0.48	0.47	1.12E-02	0.07	5.88E-05	3.86E-04	1,220.48	0.02	0.06	1,238.71
Aux. Engines	1.80E-02	0.32	0.24	9.48E-03	9.20E-03	2.96E-04	1.65E-03	1.15E-06	1.02E-05	32.21	3.89E-04	1.58E-03	32.69
Tug 4 for WTG Towers (Albany to SBMT)													
Main Engines	0.74	13.31	8.98	0.48	0.47	1.12E-02	0.07	5.88E-05	3.86E-04	1,220.48	0.02	0.06	1,238.71
Aux. Engines	1.80E-02	0.32	0.24	9.48E-03	9.20E-03	2.96E-04	1.65E-03	1.15E-06	1.02E-05	32.21	3.89E-04	1.58E-03	32.69
Cargo Barge 3 (WTG Towers Albany to SBMT)													
TOTALS	**3.54**	**61.15**	**36.62**	**2.80**	**2.71**	**0.10**	**0.34**	**3.38E-04**	**3.61E-03**	**5,072.78**	**0.08**	**0.25**	**5,148.07**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-13. EW 1 Wind Turbine Installation Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 57 wind turbine locations for EW 1.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   - Overseas port to local staging area at SBMT: 13.5 nm in NY/NJ state waters
   - South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
   - Port of Albany to South Brooklyn Marine Terminal: 128.3 nm
   - Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
3. The number of transits for each vessel are based on the following assumptions:
   - 1 round trip to/from overseas port for the main installation vessel.
   - 19 round trips from overseas port to local staging area at SBMT for the turbine supply vessel, based on assumed capacity to transport components for three positions per trip (for 57 total positions).
   - 29 round trips to/from SBMT for each WTG component tug (for 57 total positions).
   - 19 round trips to/from Port of Albany for each WTG tower tug (for 57 total positions).
4. Helicopter transit emissions assume two round trips per week, with a duration of 30 minutes per round trip, based on travel from JFK Int'l Airport (30 mi one-way distance, 1.5 mi over Queens County, 8.5 mi over Nassau County, and 20 mi inside OCS radius).
5. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
6. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
7. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
8. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
9. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
10. WTG installation generator could be a vessel engine connected directly to WTG tower; emissions based on Category 2 marine engine.
11. WTG commissioning generator will be portable generator lifted onto WTG platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
12. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
13. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-14. EW 2 Wind Turbine Installation Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Helicopter - Twin-Engine Heavy		N/A							
Main Engines	2			164	1,400	Jet fuel	N/A	N/A	N/A
Main Installation Vessel		3	469 x 273 x 36 (25)						
Main Engines	6			5.02	6,032	Diesel	52,000	11,000	3.18
WTG Installation Generator									
	1	N/A	N/A	1.21	1,609	Diesel	0	6,150	3.18
WTG Commissioning Generators									
	3	N/A	N/A	257	201	Diesel	2,112	2,112	3.18
Tug 1 for WTG Blades/Nacelles (from SBMT)		N/A	146 x 46 x 25 (21)						
Main Engines	2			2.10	5,440	Diesel	19,000	6,000	3.18
Harbor Engine	1			2.07	456	Diesel			
Emergency Engine	1			2.05	168	Diesel			
Tug 2 for WTG Blades/Nacelles (from SBMT)		N/A	146 x 46 x 25 (21)						
Main Engines	2			2.10	5,440	Diesel	19,000	6,000	3.18
Harbor Engine	1			2.07	456	Diesel			
Emergency Engine	1			2.05	168	Diesel			
Cargo Barge 1 (WTG Blades/Nacelles/Towers from SBMT)		N/A	400 x 105 x 25						
							0	0	N/A
Cargo Barge 2 (WTG Blades/Nacelles/Towers from SBMT)		N/A	400 x 105 x 25						
							0	0	N/A
Tug 3 for WTG Towers (Albany to SBMT)		N/A	127 x 36 x 19 (17)						
Main Engines	2			2.08	3,600	Diesel	10,000	0	3.18
Aux. Engines	2			2.06	95	Diesel			
Tug 4 for WTG Towers (Albany to SBMT)		N/A	127 x 36 x 19 (17)						
Main Engines	2			2.08	3,600	Diesel	10,000	0	3.18
Aux. Engines	2			2.06	95	Diesel			
Cargo Barge 3 (WTG Towers Albany to SBMT)		N/A	400 x 105 x 25						
							0	0	N/A
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-14. EW 2 Wind Turbine Installation Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Helicopter - Twin-Engine Heavy										
Main Engines	102	0.5	0	0	0	0	100%	0%	16,052	0
Main Installation Vessel										
Main Engines	1	6	0	349	24	8,376	39%	8%	4,088	1,207,233
WTG Installation Generator										
	0	0	0	34	24	816	0%	100%	0	65,755
WTG Commissioning Generators										
	0	0	0	90	24	2,160	0%	95%	0	59,774
Tug 1 for WTG Blades/Nacelles (from SBMT)										
Main Engines	45	15	0	349	24	8,376	46%	14%	168,042	658,491
Harbor Engine	0	0	0	0	0	0	0%	0%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Tug 2 for WTG Blades/Nacelles (from SBMT)										
Main Engines	45	15	0	349	24	8,376	46%	14%	168,042	658,491
Harbor Engine	0	0	0	0	0	0	0%	0%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Cargo Barge 1 (WTG Blades/Nacelles/Towers from SBMT)										
	45	15	0	349	24	8,376	N/A	N/A	N/A	N/A
Cargo Barge 2 (WTG Blades/Nacelles/Towers from SBMT)										
	45	15	0	349	24	8,376	N/A	N/A	N/A	N/A
Tug 3 for WTG Towers (Albany to SBMT)										
Main Engines	30	45	0	0	24	0	35%	0%	176,887	0
Aux. Engines	30	45	0	0	24	0	35%	0%		
Tug 4 for WTG Towers (Albany to SBMT)										
Main Engines	30	45	0	0	24	0	35%	0%	176,887	0
Aux. Engines	30	45	0	0	24	0	35%	0%		
Cargo Barge 3 (WTG Towers Albany to SBMT)										
	30	45	0	0	24	0	N/A	N/A	N/A	N/A
TOTALS									**709,998**	**2,649,742**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-14. EW 2 Wind Turbine Installation Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Main Installation Vessel													
Main Engines	43.47	53.61	103.21	3.85	3.55	8.27	3.58	4.43E-04	0.28	13,566.84	0.21	0.60	13,750.39
WTG Installation Generator													
	0.11	8.52	2.00	0.25	0.24	5.04E-03	0.01	3.02E-05	1.73E-04	548.50	0.00	0.03	556.55
WTG Commissioning Generators													
	0.21	0.41	3.58	0.02	0.02	1.53E-03	0.02	3.11E-06	5.27E-05	166.65	6.76E-03	1.35E-03	167.22
Tug 1 for WTG Blades/Nacelles (from SBMT)													
Main Engines	5.59	100.89	54.18	5.42	5.26	0.07	0.56	6.57E-04	2.33E-03	7,363.16	0.11	0.36	7,473.17
Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 2 for WTG Blades/Nacelles (from SBMT)													
Main Engines	5.59	100.89	54.18	5.42	5.26	0.07	0.56	6.57E-04	2.33E-03	7,363.16	0.11	0.36	7,473.17
Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Cargo Barge 1 (WTG Blades/Nacelles/Towers from SBMT)													
Cargo Barge 2 (WTG Blades/Nacelles/Towers from SBMT)													
Tug 3 for WTG Towers (Albany to SBMT)													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 4 for WTG Towers (Albany to SBMT)													
Main Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Aux. Engines	0	0	0	0	0	0	0	0	0	0	0	0	0
Cargo Barge 3 (WTG Towers Albany to SBMT)													
TOTALS	**54.98**	**264.31**	**217.16**	**14.96**	**14.32**	**8.42**	**4.74**	**1.79E-03**	**0.29**	**29,008.31**	**0.43**	**1.35**	**29,420.51**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-14. EW 2 Wind Turbine Installation Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy													
Main Engines	0.07	0.88	0.02	0.02	0.02	0.05	1.76E-03	8.53E-07	1.85E-03	169.33	4.85E-03	5.61E-03	171.12
Main Installation Vessel													
Main Engines	0.15	0.18	0.35	1.31E-02	1.20E-02	0.03	1.21E-02	1.50E-06	9.64E-04	45.94	6.99E-04	2.03E-03	46.56
WTG Installation Generator													
	0	0	0	0	0	0	0	0	0	0	0	0	0
WTG Commissioning Generators													
	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 1 for WTG Blades/Nacelles (from SBMT)													
Main Engines	1.43	25.75	13.83	1.38	1.34	0.02	0.14	1.68E-04	5.94E-04	1,879.03	0.03	0.09	1,907.10
Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 2 for WTG Blades/Nacelles (from SBMT)													
Main Engines	1.43	25.75	13.83	1.38	1.34	0.02	0.14	1.68E-04	5.94E-04	1,879.03	0.03	0.09	1,907.10
Harbor Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Cargo Barge 1 (WTG Blades/Nacelles/Towers from SBMT)													
Cargo Barge 2 (WTG Blades/Nacelles/Towers from SBMT)													
Tug 3 for WTG Towers (Albany to SBMT)													
Main Engines	1.16	21.02	14.18	0.77	0.74	0.02	0.11	9.28E-05	6.10E-04	1,927.07	0.03	0.09	1,955.87
Aux. Engines	0.03	0.51	0.37	0.01	0.01	4.67E-04	2.60E-03	1.81E-06	1.61E-05	50.85	6.14E-04	2.49E-03	51.61
Tug 4 for WTG Towers (Albany to SBMT)													
Main Engines	1.16	21.02	14.18	0.77	0.74	0.02	0.11	9.28E-05	6.10E-04	1,927.07	0.03	0.09	1,955.87
Aux. Engines	0.03	0.51	0.37	0.01	0.01	4.67E-04	2.60E-03	1.81E-06	1.61E-05	50.85	6.14E-04	2.49E-03	51.61
Cargo Barge 3 (WTG Towers Albany to SBMT)													
TOTALS	**5.46**	**95.61**	**57.13**	**4.36**	**4.23**	**0.15**	**0.53**	**5.27E-04**	**0.01**	**7,929.19**	**0.12**	**0.38**	**8,046.85**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-14. EW 2 Wind Turbine Installation Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 90 wind turbine locations for EW 2.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   - Overseas port to local staging area at SBMT: 13.5 nm in NY/NJ state waters
   - South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
   - Port of Albany to South Brooklyn Marine Terminal: 128.3 nm
   - Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
3. The number of transits for each vessel are based on the following assumptions:
   - 1 round trip to/from overseas port for the main installation vessel.
   - 30 round trips from overseas port to local staging area at SBMT for the turbine supply vessel, based on assumed capacity to transport components for three positions per trip (for 90 total positions).
   - 45 round trips to/from SBMT for each WTG component tug (45 barge trips total for 90 total positions).
   - 30 round trips to/from Port of Albany for each WTG tower tug (for 90 total positions).
4. Helicopter transit emissions assume two round trips per week, with a duration of 30 minutes per round trip, based on travel from JFK Int'l Airport (30 mi one-way distance, 1.5 mi over Queens County, 8.5 mi over Nassau County, and 20 mi inside OCS radius).
5. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
6. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
7. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
8. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
9. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
10. WTG installation generator could be a vessel engine connected directly to WTG tower; emissions based on Category 2 marine engine.
11. WTG commissioning generator will be portable generator lifted onto WTG platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
12. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
13. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-15. EW 1 Commissioning Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Service Operations Vessel 1		1	275 x 58 x 21						
Main Engines	4			2.07	2,212	Diesel	10,000	10,000	3.18
Crew Transfer Vessel 1 (Primary)		N/A	65 x 17 x 5						
Main Engines	2			4.02	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			3.03	27	Diesel			
Crew Transfer Vessel 2		N/A	65 x 17 x 5						
Main Engines	2			2.06	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			2.03	27	Diesel			
Crew Transfer Vessel 3		N/A	65 x 17 x 5						
Main Engines	2			2.06	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			2.03	27	Diesel			
Jack-up Vessel for OSS Hookup & Commissioning		3	178 x 135 x 15 (10)						
Main Engines	2			2.07	3,150	Diesel	15,000	4,000	3.18
Aux. Engines	2			2.07	1,340	Diesel			
Emergency Engine	1			2.05	212	Diesel			
Inter-array Cable Pulling Engine (at each WTG)	1	N/A	N/A	254	20	Diesel	0	74	3.18
Inter-array Cable Pulling Engine (at OSS)	1	N/A	N/A	254	20	Diesel	0	74	3.18
Inter-array Cable Pulling Engine (at OSS)	1	N/A	N/A	255	34	Diesel	0	123	3.18
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-15. EW 1 Commissioning Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Service Operations Vessel 1										
Main Engines	30	9	0	420	24	10,080	30%	30%	35,377	1,320,755
Crew Transfer Vessel 1 (Primary)										
Main Engines	60	9	0	420	24	10,080	64%	51%	35,377	528,302
Main Engines	60	9	0	420	24	10,080	64%	51%		
Crew Transfer Vessel 2										
Main Engines	47	9	0	330	24	7,920	64%	51%	27,712	415,094
Main Engines	47	9	0	330	24	7,920	64%	51%		
Crew Transfer Vessel 3										
Main Engines	30	9	0	210	24	5,040	64%	51%	17,689	264,151
Main Engines	30	9	0	210	24	5,040	64%	51%		
Jack-up Vessel for OSS Hookup & Commissioning										
Main Engines	2	6	0	270	24	6,480	44%	12%	2,358	339,623
Aux. Engines	2	6	0	270	24	6,480	44%	12%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Inter-array Cable Pulling Engine (at each WTG)	0	0	0	119	24	2,856	0%	100%	0	2,769
Inter-array Cable Pulling Engine (at OSS)	0	0	0	4	24	96	0%	100%	0	93
Export Cable Pulling Engine (at OSS)	0	0	0	4	24	96	0%	100%	0	155
TOTALS									**118,514**	**2,870,942**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-15. EW 1 Commissioning Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Service Operations Vessel 1													
Main Engines	8.24	148.67	108.68	4.35	4.22	0.14	0.75	5.27E-04	4.67E-03	14,768.52	0.18	0.72	14,988.20
Crew Transfer Vessel 1 (Primary)													
Main Engines	1.69	15.24	42.34	0.34	0.33	0.05	0.14	4.11E-05	1.82E-03	5,753.17	0.07	0.28	5,838.74
Main Engines	0.06	1.01	1.14	0.07	0.07	1.42E-03	5.94E-03	8.26E-06	4.88E-05	154.24	0.00	7.54E-03	156.53
Crew Transfer Vessel 2													
Main Engines	2.52	45.50	33.26	1.33	1.29	0.04	0.23	1.61E-04	1.43E-03	4,520.35	0.05	0.22	4,587.58
Main Engines	0.07	1.27	0.98	0.11	0.10	1.11E-03	7.98E-03	1.30E-05	3.83E-05	121.19	0.00	5.93E-03	122.99
Crew Transfer Vessel 3													
Main Engines	1.60	28.96	21.17	0.85	0.82	0.03	0.15	1.03E-04	9.10E-04	2,876.58	0.03	0.14	2,919.37
Main Engines	0.05	0.81	0.62	0.07	0.07	7.09E-04	5.08E-03	8.26E-06	2.44E-05	77.12	9.31E-04	3.77E-03	78.27
Jack-up Vessel for OSS Hookup & Commissioning													
Main Engines	1.49	26.82	19.60	0.78	0.76	0.02	0.14	9.51E-05	8.43E-04	2,664.00	0.03	0.13	2,703.63
Aux. Engines	0.63	11.41	8.34	0.33	0.32	1.04E-02	0.06	4.05E-05	3.59E-04	1,133.62	0.01	0.06	1,150.48
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-array Cable Pulling Engine (at each WTG)	0.02	0.34	0.31	0.02	0.02	7.10E-05	7.30E-04	1.44E-07	2.44E-06	7.72	3.13E-04	6.26E-05	7.75
Inter-array Cable Pulling Engine (at OSS)	6.39E-04	1.13E-02	1.05E-02	6.37E-04	6.18E-04	2.39E-06	2.45E-05	4.85E-09	8.21E-08	0.26	1.05E-05	2.11E-06	0.26
Export Cable Pulling Engine (at OSS)	6.65E-04	1.18E-02	1.32E-02	7.94E-05	7.70E-05	3.97E-06	4.08E-05	8.06E-09	1.37E-07	0.43	1.75E-05	3.50E-06	0.43
TOTALS	**16.37**	**280.06**	**236.47**	**8.24**	**8.00**	**0.29**	**1.49**	**9.97E-04**	**1.01E-02**	**32,077.19**	**0.39**	**1.57**	**32,554.24**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-15. EW 1 Commissioning Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Service Operations Vessel 1													
Main Engines	0.22	3.98	2.91	0.12	0.11	3.64E-03	2.02E-02	1.41E-05	1.25E-04	395.59	0.00	1.93E-02	401.47
Crew Transfer Vessel 1 (Primary)													
Main Engines	0.11	1.02	2.83	0.02	0.02	3.54E-03	9.62E-03	2.75E-06	1.22E-04	385.26	0.00	1.88E-02	390.99
Main Engines	3.76E-03	0.07	0.08	4.56E-03	4.42E-03	9.49E-05	3.97E-04	5.53E-07	3.27E-06	10.33	1.25E-04	5.05E-04	10.48
Crew Transfer Vessel 2													
Main Engines	0.17	3.04	2.22	0.09	0.09	2.77E-03	1.54E-02	1.08E-05	9.55E-05	301.78	0.00	1.48E-02	306.27
Main Engines	4.78E-03	0.08	0.07	7.14E-03	6.93E-03	7.44E-05	5.33E-04	8.66E-07	2.56E-06	8.09	9.76E-05	3.96E-04	8.21
Crew Transfer Vessel 3													
Main Engines	0.11	1.94	1.42	0.06	0.05	1.77E-03	9.84E-03	6.87E-06	6.09E-05	192.63	0.00	9.42E-03	195.49
Main Engines	3.05E-03	0.05	0.04	4.56E-03	4.42E-03	4.75E-05	3.40E-04	5.53E-07	1.63E-06	5.16	6.23E-05	2.53E-04	5.24
Jack-up Vessel for OSS Hookup & Commissioning													
Main Engines	1.03E-02	0.19	0.14	5.45E-03	5.28E-03	1.70E-04	9.45E-04	6.60E-07	5.85E-06	18.50	2.23E-04	9.05E-04	18.78
Aux. Engines	4.39E-03	0.08	0.06	2.32E-03	2.25E-03	7.24E-05	4.02E-04	2.81E-07	2.49E-06	7.87	9.50E-05	3.85E-04	7.99
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-array Cable Pulling Engine (at each WTG)	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-array Cable Pulling Engine (at OSS)	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Pulling Engine (at OSS)	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**0.64**	**10.45**	**9.76**	**0.31**	**0.30**	**1.22E-02**	**0.06**	**3.74E-05**	**4.19E-04**	**1,325.21**	**0.02**	**0.06**	**1,344.92**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)\ *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-15. EW 1 Commissioning Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 57 wind turbine locations for EW 1.
2. Transit emissions are based on an assumed vessel speed of 10 knots, and the following one-way travel distances:
   South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
3. The number of transits for each vessel are based on the following assumptions:
   Biweekly round trips to/from port for the service operations vessel.
   Weekly round trips to/from port for the crew transfer vessels.
   2 round trips to/from overseas port for jack-up vessel.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
6. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
8. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
9. Inter-array cable pulling engine (at each WTG) will be a portable generator lifted onto WTG platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
10. Inter-array cable pulling engine (at OSS) will be a portable generator lifted onto OSS platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
11. Export cable pulling engine (at OSS) will be a portable generator lifted onto OSS platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
12. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
13. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-16. EW 2 Commissioning Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Service Operations Vessel 1		1	275 x 58 x 21						
Main Engines	4			2.07	2,212	Diesel	10,000	10,000	3.18
Crew Transfer Vessel 1 (Primary)		N/A	65 x 17 x 5						
Main Engines	2			4.02	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			3.03	27	Diesel			
Crew Transfer Vessel 2		N/A	65 x 17 x 5						
Main Engines	2			2.06	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			2.03	27	Diesel			
Crew Transfer Vessel 3		N/A	65 x 17 x 5						
Main Engines	2			2.06	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			2.03	27	Diesel			
Jack-up Vessel for OSS Hookup & Commissioning		3	178 x 135 x 15 (10)						
Main Engines	2			2.07	3,150	Diesel	15,000	4,000	3.18
Aux. Engines	2			2.07	1,340	Diesel			
Emergency Engine	1			2.05	212	Diesel			
Inter-array Cable Pulling Engine (at each WTG)	1	N/A	N/A	254	20	Diesel	0	74	3.18
Inter-array Cable Pulling Engine (at OSS)	1	N/A	N/A	254	20	Diesel	0	74	3.18
Export Cable Pulling Engine (at OSS)	1	N/A	N/A	255	34	Diesel	0	123	3.18
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-16. EW 2 Commissioning Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Service Operations Vessel 1										
Main Engines	39	9	0	540	24	12,960	30%	30%	45,991	1,698,113
Crew Transfer Vessel 1 (Primary)										
Main Engines	77	9	0	540	24	12,960	64%	51%	45,401	679,245
Main Engines	77	9	0	540	24	12,960	64%	51%		
Crew Transfer Vessel 2										
Main Engines	56	9	0	390	24	9,360	64%	51%	33,019	490,566
Main Engines	56	9	0	390	24	9,360	64%	51%		
Crew Transfer Vessel 3										
Main Engines	34	9	0	240	24	5,760	64%	51%	20,047	301,887
Main Engines	34	9	0	240	24	5,760	64%	51%		
Jack-up Vessel for OSS Hookup & Commissioning										
Main Engines	2	6	0	270	24	6,480	44%	12%	2,358	339,623
Aux. Engines	2	6	0	270	24	6,480	44%	12%		
Emergency Engine	0	0	0	0	0	0	0%	0%		
Inter-array Cable Pulling Engine (at each WTG)	0	0	0	188	24	4,512	0%	100%	0	4,375
Inter-array Cable Pulling Engine (at OSS)	0	0	0	4	24	96	0%	100%	0	93
Export Cable Pulling Engine (at OSS)	0	0	0	4	24	96	0%	100%	0	155
TOTALS									**146,816**	**3,514,057**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-16. EW 2 Commissioning Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Service Operations Vessel 1													
Main Engines	10.59	191.15	139.73	5.59	5.42	0.17	0.97	6.78E-04	6.01E-03	18,988.10	0.23	0.93	19,270.54
Crew Transfer Vessel 1 (Primary)													
Main Engines	2.18	19.60	54.43	0.44	0.42	0.07	0.18	5.28E-05	2.34E-03	7,396.93	0.09	0.36	7,506.96
Main Engines	0.07	1.30	1.46	0.09	0.08	1.82E-03	7.63E-03	1.06E-05	6.27E-05	198.31	0.00	9.70E-03	201.26
Crew Transfer Vessel 2													
Main Engines	2.98	53.78	39.31	1.57	1.53	0.05	0.27	1.91E-04	1.69E-03	5,342.23	0.06	0.26	5,421.69
Main Engines	0.08	1.50	1.16	0.13	0.12	1.32E-03	9.43E-03	1.53E-05	4.53E-05	143.22	1.73E-03	7.00E-03	145.35
Crew Transfer Vessel 3													
Main Engines	1.83	33.09	24.19	0.97	0.94	0.03	0.17	1.17E-04	1.04E-03	3,287.52	0.04	0.16	3,336.43
Main Engines	0.05	0.92	0.71	0.08	0.08	8.10E-04	5.80E-03	9.44E-06	2.79E-05	88.14	1.06E-03	4.31E-03	89.45
Jack-up Vessel for OSS Hookup & Commissioning													
Main Engines	1.49	26.82	19.60	0.78	0.76	0.02	0.14	9.51E-05	8.43E-04	2,664.00	0.03	0.13	2,703.63
Aux. Engines	0.63	11.41	8.34	0.33	0.32	1.04E-02	0.06	4.05E-05	3.59E-04	1,133.62	0.01	0.06	1,150.48
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-array Cable Pulling Engine (at each WTG)	0.03	0.53	0.49	0.03	0.03	1.12E-04	1.15E-03	2.28E-07	3.86E-06	12.20	4.95E-04	9.89E-05	12.24
Inter-array Cable Pulling Engine (at OSS)	6.39E-04	1.13E-02	1.05E-02	6.37E-04	6.18E-04	2.39E-06	2.45E-05	4.85E-09	8.21E-08	0.26	1.05E-05	2.11E-06	0.26
Export Cable Pulling Engine (at OSS)	6.65E-04	1.18E-02	1.32E-02	7.94E-05	7.70E-05	3.97E-06	4.08E-05	8.06E-09	1.37E-07	0.43	1.75E-05	3.50E-06	0.43
TOTALS	**19.95**	**340.13**	**289.46**	**10.00**	**9.70**	**0.36**	**1.81**	**1.21E-03**	**1.24E-02**	**39,254.95**	**0.47**	**1.92**	**39,838.71**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-16. EW 2 Commissioning Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Service Operations Vessel 1													
Main Engines	0.29	5.18	3.78	0.15	0.15	4.73E-03	2.63E-02	1.84E-05	1.63E-04	514.26	0.01	2.51E-02	521.91
Crew Transfer Vessel 1 (Primary)													
Main Engines	0.15	1.31	3.64	0.03	0.03	4.54E-03	1.23E-02	3.53E-06	1.56E-04	494.41	0.01	2.42E-02	501.77
Main Engines	4.83E-03	0.09	0.10	5.85E-03	5.68E-03	1.22E-04	5.10E-04	7.10E-07	4.19E-06	13.26	1.60E-04	6.48E-04	13.45
Crew Transfer Vessel 2													
Main Engines	0.20	3.62	2.65	0.11	0.10	3.31E-03	1.84E-02	1.28E-05	1.14E-04	359.57	0.00	1.76E-02	364.92
Main Engines	5.69E-03	0.10	0.08	8.51E-03	8.26E-03	8.86E-05	6.35E-04	1.03E-06	3.05E-06	9.64	1.16E-04	4.71E-04	9.78
Crew Transfer Vessel 3													
Main Engines	0.12	2.20	1.61	0.06	0.06	2.01E-03	1.12E-02	7.79E-06	6.90E-05	218.31	0.00	1.07E-02	221.56
Main Engines	3.46E-03	0.06	0.05	5.17E-03	5.01E-03	5.38E-05	3.85E-04	6.27E-07	1.85E-06	5.85	7.06E-05	2.86E-04	5.94
Jack-up Vessel for OSS Hookup & Commissioning													
Main Engines	1.03E-02	0.19	0.14	5.45E-03	5.28E-03	1.70E-04	9.45E-04	6.60E-07	5.85E-06	18.50	2.23E-04	9.05E-04	18.78
Aux. Engines	4.39E-03	0.08	0.06	2.32E-03	2.25E-03	7.24E-05	4.02E-04	2.81E-07	2.49E-06	7.87	9.50E-05	3.85E-04	7.99
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-array Cable Pulling Engine (at each WTG)	0	0	0	0	0	0	0	0	0	0	0	0	0
Inter-array Cable Pulling Engine (at OSS)	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Cable Pulling Engine (at OSS)	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**0.78**	**12.82**	**12.09**	**0.38**	**0.37**	**1.51E-02**	**0.07**	**4.58E-05**	**5.19E-04**	**1,641.68**	**0.02**	**0.08**	**1,666.10**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)\ *\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-16. EW 2 Commissioning Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 90 wind turbine locations for EW 2.
2. Transit emissions are based on an assumed vessel speed of 10 knots, and the following one-way travel distances:
   South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
3. The number of transits for each vessel are based on the following assumptions:
   Biweekly round trips to/from port for the service operations vessel.
   Weekly round trips to/from port for the crew transfer vessels.
   2 round trips to/from overseas port for jack-up vessel.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
6. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
8. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the $PM_{2.5}$ or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
9. Inter-array cable pulling engine (at each WTG) will be a portable generator lifted onto WTG platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
10. Inter-array cable pulling engine (at OSS) will be a portable generator lifted onto OSS platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
11. Export cable pulling engine (at OSS) will be a portable generator lifted onto OSS platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
12. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
13. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-17. EW 1 Substation, O+M Base, and Onshore Cable Route - Construction Emissions

								Fuel Use	Emissions												
Construction Equipment	**Source Category**	**HP per unit**	**Fuel Type**	**Emiss. Factor ID**	**hrs per day**	**Load Factor**	**Total Equip. Months**	**gal**	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAP Tons**	**Pb Tons**	**H_2SO_4 Tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Land-based Nonroad Equip.																					
SUBSTATION																					
Large Bulldozer	2270002069	800	diesel	96	8	59%	9	27,962	0.17	2.16	0.47	0.06	0.06	2.16E-03	0.04	0	7.43E-05	421.85	1.31E-02	1.07E-02	425.38
All-Terrain Forklift	2270002057	150	diesel	94	8	59%	30	17,480	0.09	0.44	0.18	0.04	0.04	1.36E-03	0.02	0	4.68E-05	263.71	7.03E-03	6.72E-03	265.88
Front End Loader	2270002060	200	diesel	95	8	59%	15	11,654	0.05	0.21	0.07	9.57E-03	9.28E-03	8.73E-04	1.28E-02	0	3.01E-05	175.82	4.42E-03	4.48E-03	177.26
Medium Crane	2270002045	400	diesel	93	8	43%	12	13,442	0.07	0.54	0.15	0.02	0.02	1.09E-03	0.02	0	3.77E-05	202.79	5.21E-03	5.16E-03	204.46
Medium Aerial Lift	2270003010	20	diesel	99	8	21%	48	1,713	0.05	0.20	0.19	0.03	0.03	1.74E-04	1.12E-02	0	6.00E-06	25.85	1.60E-03	6.58E-04	26.08
Medium Excavator	2270002036	200	diesel	92	8	59%	12	9,324	0.04	0.10	0.04	3.66E-03	3.55E-03	6.82E-04	9.85E-03	0	2.35E-05	140.66	3.42E-03	3.58E-03	141.81
Piling Rig	2270002033	200	diesel	91	8	43%	3	1,680	1.19E-02	0.12	0.03	5.72E-03	5.55E-03	1.44E-04	2.86E-03	0	4.97E-06	25.34	6.63E-04	6.45E-04	25.55
Generator	2270006005	150	diesel	100	8	43%	5	2,099	0.02	0.16	0.04	9.30E-03	9.03E-03	1.84E-04	4.00E-03	0	6.31E-06	31.67	8.72E-04	8.06E-04	31.93
ONSHORE CABLE																					
Onshore Cable Route HDD Drill Rig	2270002033	200	diesel	91	8	43%	3	1,680	1.19E-02	0.12	0.03	5.72E-03	5.55E-03	1.44E-04	2.86E-03	0	4.97E-06	25.34	6.63E-04	6.45E-04	25.55
Onshore Cable Route Compressor	2270006015	150	diesel	102	8	43%	3	1,260	6.41E-03	0.04	1.09E-02	2.49E-03	2.42E-03	1.00E-04	1.54E-03	0	3.45E-06	19.01	5.17E-04	4.84E-04	19.17
Onshore Cable Route Excavator	2270002036	200	diesel	92	8	59%	6	4,662	0.02	0.05	0.02	1.83E-03	1.77E-03	3.41E-04	4.92E-03	0	1.17E-05	70.33	1.71E-03	1.79E-03	70.91
Onshore Cable Route Tractor	2270002075	450	diesel	97	8	59%	3	5,244	0.02	0.16	0.06	8.84E-03	8.58E-03	4.13E-04	5.84E-03	0	1.42E-05	79.12	2.00E-03	2.01E-03	79.77
O&M BASE																					
250T Shore Crane	2270002045	400	diesel	93	8	43%	5	5,601	0.03	0.22	0.06	9.31E-03	9.03E-03	4.56E-04	6.66E-03	0	1.57E-05	84.50	2.17E-03	2.15E-03	85.19
5T Forklift	2270002057	115	diesel	94	6	59%	6	2,010	9.86E-03	0.05	0.02	4.30E-03	4.17E-03	1.56E-04	2.37E-03	0	5.38E-06	30.33	8.08E-04	7.72E-04	30.58
All-Terrain Forklift	2270002057	150	diesel	94	8	59%	10	5,827	0.03	0.15	0.06	1.25E-02	1.21E-02	4.53E-04	6.87E-03	0	1.56E-05	87.90	2.34E-03	2.24E-03	88.63
Front End Loader	2270002060	200	diesel	95	8	59%	10	7,769	0.04	0.14	0.05	6.38E-03	6.19E-03	5.82E-04	8.53E-03	0	2.00E-05	117.21	2.95E-03	2.98E-03	118.17
Medium Crane	2270002045	400	diesel	93	8	43%	10	11,202	0.06	0.45	0.12	0.02	0.02	9.12E-04	1.33E-02	0	3.14E-05	168.99	4.34E-03	4.30E-03	170.39
Medium Aerial Lift	2270003010	20	diesel	99	8	21%	10	357	9.67E-03	0.04	0.04	5.40E-03	5.23E-03	3.63E-05	2.32E-03	0	1.25E-06	5.39	3.34E-04	1.37E-04	5.43
Medium Excavator	2270002036	200	diesel	92	8	59%	10	7,770	0.03	0.08	0.03	3.05E-03	2.95E-03	5.69E-04	8.21E-03	0	1.96E-05	117.22	2.85E-03	2.98E-03	118.18
Piling Rig	2270002033	200	diesel	91	8	43%	1	560	3.97E-03	0.04	9.16E-03	1.91E-03	1.85E-03	4.81E-05	9.54E-04	0	1.66E-06	8.45	2.21E-04	2.15E-04	8.52
CABLE LANDFALL AND BULKHEAD																					
250T Shore Crane	2270002045	400	diesel	93	8	43%	7	7,841	0.04	0.31	0.08	1.30E-02	1.26E-02	6.38E-04	9.32E-03	0	2.20E-05	118.30	3.04E-03	3.01E-03	119.27
Large excavator	2270002036	350	diesel	92	12	59%	8	16,316	0.07	0.17	0.06	6.40E-03	6.20E-03	1.19E-03	0.02	0	4.11E-05	246.15	5.98E-03	6.27E-03	248.17
Medium Bulldozer	2270002069	390	diesel	96	6	59%	8	9,088	0.05	0.70	0.15	0.02	0.02	7.02E-04	1.31E-02	0	2.42E-05	137.10	4.25E-03	3.49E-03	138.25
5T Forklift	2270002057	115	diesel	94	6	59%	6	2,010	9.86E-03	0.05	0.02	4.30E-03	4.17E-03	1.56E-04	2.37E-03	0	5.38E-06	30.33	8.08E-04	7.72E-04	30.58
Onroad Vehicles																					
Semi-Truck		-	diesel	131	-	-	9	1,878	4.77E-03	0.04	0.02	1.36E-03	1.25E-03	1.77E-04	6.17E-04	0	6.10E-06	21.14	2.02E-03	8.13E-05	21.21
Work Truck		-	diesel	133	-	-	15	1,391	7.19E-03	0.02	0.06	8.75E-04	8.05E-04	1.32E-04	9.63E-04	0	4.53E-06	15.65	3.19E-03	9.45E-05	15.76
Refuse Truck		-	diesel	132	-	-	9	2,387	2.28E-03	0.03	1.18E-02	9.76E-04	8.98E-04	2.24E-04	3.41E-04	0	7.72E-06	26.87	1.49E-03	7.37E-05	26.93
Dump Truck		-	diesel	131	-	-	68	14,191	0.04	0.27	0.13	1.03E-02	9.45E-03	1.34E-03	4.66E-03	0	4.61E-05	159.71	0.02	6.14E-04	160.27
Concrete Truck		-	diesel	131	-	-	9	1,878	4.77E-03	0.04	0.02	1.36E-03	1.25E-03	1.77E-04	6.17E-04	0	6.10E-06	21.14	2.02E-03	8.13E-05	21.21
Worker Commute																					
Light Commercial Truck		-	diesel	134	-	-	60	4,274	1.21E-02	0.05	0.10	1.35E-03	1.25E-03	4.02E-04	2.17E-03	0	1.38E-05	48.10	9.68E-03	2.97E-04	48.43
Passenger Truck		-	gasoline	135	-	-	36	2,020	9.69E-03	8.27E-03	0.15	3.92E-04	3.46E-04	2.80E-04	9.24E-04	0	9.65E-06	19.55	5.02E-04	4.79E-04	19.70
							Total	**202,569**	**1.01**	**7.14**	**2.47**	**0.31**	**0.30**	**0.02**	**0.23**	**0**	**5.61E-04**	**2,945.48**	**0.11**	**0.07**	**2,968.62**

Notes:

1. Equipment assumptions based on information provided by the project.
2. Calculations assume equipment is used 5 days/wk - i.e., 21 days/month.
3. Calculations conservatively assume that onroad vehicles travel approximately 50 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
4. Calculations conservatively assume workers average daily round trip commute is approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
5. Nonroad emission factors for criteria pollutants and GHG were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2022.
6. Nonroad emission factors for HAPs were estimated using ERG, "Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory," Volume I - Methodology, October 7, 2003.
7. Onroad vehicle emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were estimated using the MOVES2014b emission model for an assumed construction year of 2022.
8. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate.
9. Footprint for onshore substation is assumed to be 11.5 acres.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-18. EW 2 Substation and Onshore Cable Route (Direct Pipe Option) - Construction Emissions

								Fuel Use	Emissions													
Construction Equipment	**Source Category**	**HP per unit**	**Fuel Type**	**Emiss. Factor ID**	**hrs per day**	**Load Factor**	**Total Equip. Months**	**gal**	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAP Tons**	**Pb Tons**	**H_2SO_4 Tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Land-based Nonroad Equip.																						
ONSHORE SUBSTATION																						
Large Bulldozer	2270002069	800	diesel	116	8	59%	18	55,925	0.34	4.31	0.94	0.12	0.11	4.32E-03	0.08	0	1.49E-04	843.70	0.03	0.02	850.76
All-Terrain Forklift	2270002057	150	diesel	114	8	59%	30	17,480	0.09	0.44	0.18	0.04	0.04	1.36E-03	0.02	0	4.68E-05	263.71	7.03E-03	6.72E-03	265.88
Front End Loader	2270002060	200	diesel	115	8	59%	30	23,308	0.11	0.42	0.14	0.02	0.02	1.75E-03	0.03	0	6.01E-05	351.63	8.84E-03	8.95E-03	354.52
Medium Crane	2270002045	400	diesel	113	8	43%	12	13,442	0.07	0.54	0.15	0.02	0.02	1.09E-03	0.02	0	3.77E-05	202.79	5.21E-03	5.16E-03	204.46
Medium Aerial Lift	2270003010	20	diesel	119	8	21%	48	1,713	0.05	0.20	0.19	0.03	0.03	1.74E-04	1.12E-02	0	6.00E-06	25.85	1.60E-03	6.58E-04	26.08
Medium Excavator	2270002036	200	diesel	112	8	59%	36	27,971	0.12	0.29	0.11	1.10E-02	1.06E-02	2.05E-03	0.03	0	7.04E-05	421.98	1.03E-02	1.07E-02	425.43
Piling Rig	2270002033	200	diesel	111	8	43%	3	1,680	1.19E-02	0.12	0.03	5.72E-03	5.55E-03	1.44E-04	2.86E-03	0	4.97E-06	25.34	6.63E-04	6.45E-04	25.55
Generator	2270006005	150	diesel	120	8	43%	5	2,099	0.02	0.16	0.04	9.30E-03	9.03E-03	1.84E-04	4.00E-03	0	6.31E-06	31.67	8.72E-04	8.06E-04	31.93
ONSHORE CABLE (DIRECT PIPE OPTION)																						
Power plant (control unit & pipe thruster)	2270006005	300	diesel	120	8	43%	10	8,396	0.07	0.62	0.17	0.04	0.04	7.34E-04	0.02	0	2.53E-05	126.67	3.49E-03	3.23E-03	127.72
Separation plant	2270006005	150	diesel	120	8	43%	10	4,198	0.03	0.31	0.09	0.02	1.81E-02	3.67E-04	8.01E-03	0	1.26E-05	63.34	1.74E-03	1.61E-03	63.86
Mud pumps	2270006010	600	diesel	121	8	43%	16	26,877	0.17	1.88	0.54	0.08	0.08	2.32E-03	0.04	0	7.98E-05	405.48	9.65E-03	1.03E-02	408.79
Pneumatic hammer	2270006005	150	diesel	120	8	43%	10	4,198	0.03	0.31	0.09	0.02	1.81E-02	3.67E-04	8.01E-03	0	1.26E-05	63.34	1.74E-03	1.61E-03	63.86
Side booms	2270002075	319	diesel	117	8	59%	22	27,262	0.13	0.82	0.33	0.05	0.04	2.15E-03	0.03	0	7.38E-05	411.29	1.04E-02	1.05E-02	414.67
Excavators (3)	2270002036	131	diesel	112	8	59%	18	9,160	0.04	0.09	0.04	3.59E-03	3.48E-03	6.71E-04	9.68E-03	0	2.31E-05	138.20	3.36E-03	3.52E-03	139.33
Dewatering pumps (4)	2270006010	400	diesel	121	8	43%	40	44,795	0.28	3.13	0.89	0.13	0.13	3.87E-03	0.07	0	1.33E-04	675.79	0.02	0.02	681.32
Large crane	2270002045	500	diesel	113	8	43%	9	12,602	0.06	0.50	0.14	0.02	0.02	1.03E-03	1.50E-02	0	3.53E-05	190.12	4.88E-03	4.84E-03	191.68
Light towers	2270002027	24	diesel	110	8	43%	24	1,791	0.02	0.20	0.11	0.02	0.02	1.82E-04	5.51E-03	0	6.27E-06	27.01	1.99E-03	6.88E-04	27.27
Welders	2270006025	50	diesel	123	8	21%	24	2,147	0.03	0.20	0.16	0.02	0.02	1.90E-04	7.55E-03	0	6.54E-06	32.39	1.12E-03	8.25E-04	32.66
Onroad Vehicles																						
Semi-Truck		-	diesel	141	-	-	24	3,180	1.10E-02	0.08	0.04	3.15E-03	2.90E-03	3.01E-04	1.31E-03	0	1.04E-05	35.79	3.74E-03	1.23E-04	35.92
Work Truck		-	diesel	143	-	-	48	3,604	0.04	0.11	0.31	4.04E-03	3.71E-03	3.46E-04	4.28E-03	0	1.19E-05	40.56	9.94E-03	1.87E-04	40.87
Cable Truck		-	diesel	141	-	-	4	530	1.83E-03	1.26E-02	6.91E-03	5.24E-04	4.83E-04	5.02E-05	2.19E-04	0	1.73E-06	5.96	6.24E-04	2.04E-05	5.99
Refuse Truck		-	diesel	142	-	-	24	4,913	9.46E-03	0.15	0.05	6.39E-03	5.88E-03	4.68E-04	9.76E-04	0	1.61E-05	55.30	2.32E-03	1.01E-04	55.39
Dump Truck		-	diesel	141	-	-	76	10,070	0.03	0.24	0.13	9.97E-03	9.17E-03	9.54E-04	4.16E-03	0	3.28E-05	113.33	1.19E-02	3.88E-04	113.74
Concrete Truck		-	diesel	141	-	-	12	1,590	5.50E-03	0.04	0.02	1.57E-03	1.45E-03	1.51E-04	6.57E-04	0	5.18E-06	17.89	1.87E-03	6.13E-05	17.96
Worker Commute																						
Light Commercial Truck		-	diesel	144	-	-	60	3,112	1.48E-02	0.05	0.10	1.32E-03	1.21E-03	2.94E-04	2.18E-03	0	1.01E-05	35.02	8.12E-03	1.68E-04	35.13
Passenger Truck		-	gasoline	145	-	-	36	1,461	9.69E-03	9.62E-03	0.15	3.94E-04	3.49E-04	2.03E-04	8.97E-04	0	6.98E-06	14.14	5.25E-04	4.26E-04	14.28
							Total	**313,505**	**1.79**	**15.23**	**5.12**	**0.67**	**0.65**	**0.03**	**0.41**	**0**	**8.84E-04**	**4,618.28**	**0.15**	**0.11**	**4,655.06**

Notes:
1. Equipment assumptions based on information provided by the project.
2. Calculations assume equipment is used 5 days/wk - i.e., 21 days/month.
3. Calculations conservatively assume that onroad vehicles travel approximately 50 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
4.Calculations conservatively assume workers average daily round trip commute is approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
5. Nonroad emission factors for criteria pollutants and GHG were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2022.
6. Nonroad emission factors for HAPs were estimated using ERG, "Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory," Volume I - Methodology, October 7, 2003.
7. Onroad vehicle emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were estimated using the MOVES2014b emission model for an assumed construction year of 2022.
8. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate.
9.Footprint for onshore substation is assumed to be 11.5 acres.
10. Length of onshore transmission cable is assumed to be 3.8 miles.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-19. EW 1 Onshore Staging and Assembly at O+M Base - Construction Emissions

								Fuel Use	Emissions												
Construction Equipment	**Source Category**	**HP per unit**	**Fuel Type**	**Emiss. Factor ID**	**hrs per day**	**Load Factor**	**Total Equip. Months**	**gal**	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAP Tons**	**Pb Tons**	**H_2SO_4 Tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Land-based Nonroad Equip.																					
24-Axle SPMT (Transport)	N/A	523	diesel	257	12	21%	18	24,909	0.08	0.16	1.43	8.19E-03	7.95E-03	6.14E-04	0.02	0	2.11E-05	67	2.71E-03	5.42E-04	67.03
12-Axle SPMT (Transport)	N/A	241	diesel	257	12	21%	18	11,478	0.04	0.08	0.66	3.78E-03	3.66E-03	2.83E-04	9.21E-03	0	9.74E-06	31	1.25E-03	2.50E-04	30.89
Main Loading Crane	2270002045	900	diesel	93	12	43%	11	41,587	0.21	1.66	0.45	0.07	0.07	3.39E-03	0.05	0	1.16E-04	627.39	0.02	0.02	632.56
300T Crawler Crane	2270002045	500	diesel	93	8	43%	11	15,403	0.08	0.61	0.17	0.03	0.02	1.25E-03	0.02	0	4.31E-05	232.37	5.97E-03	5.92E-03	234.28
16T Forklift	2270002057	160	diesel	94	4	59%	9	2,797	1.37E-02	0.07	0.03	5.99E-03	5.81E-03	2.18E-04	3.30E-03	0	7.48E-06	42.19	1.12E-03	1.07E-03	42.54
5T Forklift	2270002057	115	diesel	94	4	59%	9	2,010	9.86E-03	0.05	0.02	4.30E-03	4.17E-03	1.56E-04	2.37E-03	0	5.38E-06	30.33	8.08E-04	7.72E-04	30.58
20T Hydraulic Cherrypicker	2270003010	100	diesel	99	6	21%	9	1,205	0.03	0.14	0.13	0.02	0.02	1.23E-04	7.85E-03	0	4.22E-06	18.17	1.13E-03	4.63E-04	18.34
Worker Commute																					
Light Commercial Truck		-	diesel	134	-	-	441	31,412	0.09	0.39	0.71	9.95E-03	9.16E-03	2.95E-03	0.02	0	1.02E-04	353.53	0.07	2.18E-03	355.95
Passenger Truck		-	gasoline	135	-	-	294	16,496	0.08	0.07	1.22	3.20E-03	2.83E-03	2.29E-03	7.54E-03	0	7.88E-05	159.65	4.10E-03	3.91E-03	160.92
							Total	**147,297**	**0.63**	**3.23**	**4.83**	**0.15**	**0.14**	**1.13E-02**	**0.13**	**0**	**3.88E-04**	**1,561.21**	**0.10**	**0.03**	**1,573.08**

Notes:

1. Equipment assumptions based on information provided by the project.
2. Calculations assume equipment is used 5 days/wk - i.e., 21 days/month.
3. Calculations conservatively assume that onroad vehicles travel approximately 50 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
4. Calculations conservatively assume workers average daily round trip commute is approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
5. Nonroad emission factors for criteria pollutants and GHG were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2022.
6. Nonroad emission factors for HAPs were estimated using ERG, "Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory," Volume I - Methodology, October 7, 2003.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate.
8. SPMT power pack engines will meet EPA Tier 4 final emission standards for land-based stationary engines.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-20. EW 2 Onshore Staging and Assembly at O+M Base - Construction Emissions

								Fuel Use	Emissions												
Construction Equipment	**Source Category**	**HP per unit**	**Fuel Type**	**Emiss. Factor ID**	**hrs per day**	**Load Factor**	**Total Equip. Months**	**gal**	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAP Tons**	**Pb Tons**	**H_2SO_4 Tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Land-based Nonroad Equip.																					
24-Axle SPMT (Transport)	N/A	523	diesel	257	12	21%	28	38,748	0.13	0.25	2.23	1.27E-02	1.24E-02	9.56E-04	0.03	0	3.29E-05	104	4.21E-03	8.43E-04	104.26
12-Axle SPMT (Transport)	N/A	241	diesel	257	12	21%	28	17,855	0.06	0.12	1.03	5.87E-03	5.70E-03	4.40E-04	1.43E-02	0	1.52E-05	48	1.94E-03	3.88E-04	48.04
Main Loading Crane	2270002045	900	diesel	93	12	43%	17	64,271	0.32	2.56	0.70	0.11	0.10	5.23E-03	0.08	0	1.80E-04	969.61	0.02	0.02	977.59
300T Crawler Crane	2270002045	500	diesel	93	8	43%	17	23,804	0.12	0.95	0.26	0.04	0.04	1.94E-03	0.03	0	6.67E-05	359.11	9.22E-03	9.14E-03	362.07
1300T Ring Crane	2270002045	500	diesel	93	8	43%	3	4,201	0.02	0.17	0.05	6.98E-03	6.77E-03	3.42E-04	4.99E-03	0	1.18E-05	63.37	1.63E-03	1.61E-03	63.89
16T Forklift	2270002057	160	diesel	94	4	59%	14	4,351	0.02	0.11	0.05	9.31E-03	9.03E-03	3.38E-04	5.13E-03	0	1.16E-05	65.63	1.75E-03	1.67E-03	66.18
5T Forklift	2270002057	115	diesel	94	4	59%	14	3,127	0.02	0.08	0.03	6.69E-03	6.49E-03	2.43E-04	3.69E-03	0	8.37E-06	47.17	1.26E-03	1.20E-03	47.56
20T Hydraulic Cherrypicker	2270003010	100	diesel	99	6	21%	14	1,874	0.05	0.22	0.20	0.03	0.03	1.91E-04	1.22E-02	0	6.56E-06	28.27	1.75E-03	7.20E-04	28.53
Worker Commute																					
Light Commercial Truck		-	diesel	144	-	-	504	26,139	0.12	0.39	0.84	1.11E-02	1.02E-02	2.47E-03	0.02	0	8.49E-05	294.18	0.07	1.41E-03	296.31
Passenger Truck		-	gasoline	145	-	-	336	13,639	0.09	0.09	1.39	3.68E-03	3.25E-03	1.89E-03	8.37E-03	0	6.52E-05	132.00	4.90E-03	3.98E-03	133.30
							Total	**198,008**	**0.95**	**4.94**	**6.77**	**0.23**	**0.22**	**1.40E-02**	**0.20**	**0**	**4.83E-04**	**2,111.14**	**0.12**	**0.05**	**2,127.74**

Notes:

1. Equipment assumptions based on information provided by the project.
2. Calculations assume equipment is used 5 days/wk - i.e., 21 days/month.
3. Calculations conservatively assume that onroad vehicles travel approximately 50 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
4. Calculations conservatively assume workers average daily round trip commute is approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
5. Nonroad emission factors for criteria pollutants and GHG were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2022.
6. Nonroad emission factors for HAPs were estimated using ERG, "Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory," Volume I - Methodology, October 7, 2003.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate.
8. SPMT power pack engines will meet EPA Tier 4 final emission standards for land-based stationary engines.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-21. EW 1 and EW 2 Offshore Operations Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Service Operations Vessel (Battery Power)	N/A	1	275 x 58 x 21	N/A	N/A	N/A	N/A	N/A	N/A
Service Operations Vessel (Diesel Power)		1	275 x 58 x 21						
Main Engines	3			4.02	1,877	Diesel	3,573	3,573	3.18
Emergency Engine	1			3.07	375	Diesel			
Crew Transfer Vessel 1 (Primary)		N/A	65 x 17 x 5						
Main Engines	2			4.02	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			3.03	27	Diesel			
Crew Transfer Vessel 2 (Primary)		N/A	65 x 17 x 5						
Main Engines	2			4.02	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			3.03	27	Diesel			
Crew Transfer Vessel 3 (Primary)		N/A	65 x 17 x 5						
Main Engines	2			4.02	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			3.03	27	Diesel			
Crew Transfer Vessel 4 (Primary)		N/A	65 x 17 x 5						
Main Engines	2			4.02	1,000	Diesel	5,000	4,000	3.18
Main Engines	2			3.03	27	Diesel			
Survey Vessel (every year)		N/A	180 x 39 x 14						
Main Engine	1			2.08	2,131	Diesel	3,000	3,000	3.18
Main Engines	2			2.06	402	Diesel			
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-21. EW 1 and EW 2 Offshore Operations Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Service Operations Vessel (Battery Power)	26	2.8	0	0	0	0	N/A	N/A	N/A	N/A
Service Operations Vessel (Diesel Power)										
Main Engines	26	7.6	0	328.5	24	7,884	17%	17%	9,251	369,098
Emergency Engine		0	0	0	0	0	0%	0%		
Crew Transfer Vessel 1 (Primary)										
Main Engines	120	9	0	240.9	24	5,782	64%	51%	70,755	303,019
Main Engines	120	9	0	240.9	24	5,782	64%	51%		
Crew Transfer Vessel 2 (Primary)										
Main Engines	120	9	0	240.9	24	5,782	64%	51%	70,755	303,019
Main Engines	120	9	0	240.9	24	5,782	64%	51%		
Crew Transfer Vessel 3 (Primary)										
Main Engines	120	9	0	240.9	24	5,782	64%	51%	70,755	303,019
Main Engines	120	9	0	240.9	24	5,782	64%	51%		
Crew Transfer Vessel 4 (Primary)										
Main Engines	120	9	0	240.9	24	5,782	64%	51%	70,755	303,019
Main Engines	120	9	0	240.9	24	5,782	64%	51%		
Survey Vessel (every year)										
Main Engine	1	9	0	60	24	1,440	27%	27%	354	56,604
Main Engines	1	9	0	60	24	1,440	27%	27%		
TOTALS									**292,623**	**1,637,777**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-21. EW 1 and EW 2 Offshore Operations Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Service Operations Vessel (Battery Power)	0	0	0	0	0	0	0	0	0	0	0	0	0
Service Operations Vessel (Diesel Power)													
Main Engines	1.22	10.93	30.37	0.24	0.24	0.04	0.10	2.95E-05	1.31E-03	4,127.20	0.05	0.20	4,188.60
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Crew Transfer Vessel 1 (Primary)													
Main Engines	0.97	8.74	24.28	0.19	0.19	0.03	0.08	2.36E-05	1.04E-03	3,299.85	0.04	0.16	3,348.94
Main Engines	0.03	0.58	0.65	0.04	0.04	8.13E-04	3.40E-03	4.74E-06	2.80E-05	88.47	1.07E-03	4.33E-03	89.78
Crew Transfer Vessel 2 (Primary)													
Main Engines	0.97	8.74	24.28	0.19	0.19	0.03	0.08	2.36E-05	1.04E-03	3,299.85	0.04	0.16	3,348.94
Main Engines	0.03	0.58	0.65	0.04	0.04	8.13E-04	3.40E-03	4.74E-06	2.80E-05	88.47	1.07E-03	4.33E-03	89.78
Crew Transfer Vessel 3 (Primary)													
Main Engines	0.97	8.74	24.28	0.19	0.19	0.03	0.08	2.36E-05	1.04E-03	3,299.85	0.04	0.16	3,348.94
Main Engines	0.03	0.58	0.65	0.04	0.04	8.13E-04	3.40E-03	4.74E-06	2.80E-05	88.47	1.07E-03	4.33E-03	89.78
Crew Transfer Vessel 4 (Primary)													
Main Engines	0.97	8.74	24.28	0.19	0.19	0.03	0.08	2.36E-05	1.04E-03	3,299.85	0.04	0.16	3,348.94
Main Engines	0.03	0.58	0.65	0.04	0.04	8.13E-04	3.40E-03	4.74E-06	2.80E-05	88.47	1.07E-03	4.33E-03	89.78
Survey Vessel (every year)													
Main Engine	0.28	5.01	3.38	0.18	0.18	4.22E-03	0.03	2.21E-05	1.45E-04	459.53	0.01	2.25E-02	466.40
Main Engines	0.10	1.75	1.28	0.05	0.05	1.59E-03	8.86E-03	6.19E-06	5.48E-05	173.41	0.00	8.48E-03	175.99
TOTALS	**5.61**	**54.98**	**134.76**	**1.41**	**1.37**	**0.17**	**0.48**	**1.71E-04**	**5.79E-03**	**18,313.42**	**0.22**	**0.90**	**18,585.86**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *(Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-21. EW 1 and EW 2 Offshore Operations Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Service Operations Vessel (Battery Power)	0	0	0	0	0	0	0	0	0	0	0	0	0
Service Operations Vessel (Diesel Power)													
Main Engines	0.03	0.27	0.76	6.09E-03	5.91E-03	9.51E-04	2.58E-03	7.38E-07	3.27E-05	103.44	1.25E-03	5.06E-03	104.98
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Crew Transfer Vessel 1 (Primary)													
Main Engines	0.23	2.04	5.67	0.05	0.04	7.08E-03	0.02	5.50E-06	2.44E-04	770.51	0.01	0.04	781.97
Main Engines	7.52E-03	0.14	0.15	9.12E-03	8.85E-03	1.90E-04	7.95E-04	1.11E-06	6.53E-06	20.66	2.49E-04	1.01E-03	20.96
Crew Transfer Vessel 2 (Primary)													
Main Engines	0.23	2.04	5.67	0.05	0.04	7.08E-03	0.02	5.50E-06	2.44E-04	770.51	0.01	0.04	781.97
Main Engines	7.52E-03	0.14	0.15	9.12E-03	8.85E-03	1.90E-04	7.95E-04	1.11E-06	6.53E-06	20.66	2.49E-04	1.01E-03	20.96
Crew Transfer Vessel 3 (Primary)													
Main Engines	0.23	2.04	5.67	0.05	0.04	7.08E-03	0.02	5.50E-06	2.44E-04	770.51	0.01	0.04	781.97
Main Engines	7.52E-03	0.14	0.15	9.12E-03	8.85E-03	1.90E-04	7.95E-04	1.11E-06	6.53E-06	20.66	2.49E-04	1.01E-03	20.96
Crew Transfer Vessel 4 (Primary)													
Main Engines	0.23	2.04	5.67	0.05	0.04	7.08E-03	0.02	5.50E-06	2.44E-04	770.51	0.01	0.04	781.97
Main Engines	7.52E-03	0.14	0.15	9.12E-03	8.85E-03	1.90E-04	7.95E-04	1.11E-06	6.53E-06	20.66	2.49E-04	1.01E-03	20.96
Survey Vessel (every year)													
Main Engine	1.74E-03	0.03	0.02	1.14E-03	1.11E-03	2.64E-05	1.64E-04	1.38E-07	9.08E-07	2.87	4.23E-05	1.40E-04	2.91
Main Engines	6.05E-04	0.01	7.98E-03	3.19E-04	3.09E-04	9.96E-06	5.54E-05	3.87E-08	3.43E-07	1.08	1.31E-05	5.30E-05	1.10
TOTALS	**0.97**	**9.02**	**24.08**	**0.23**	**0.22**	**0.03**	**0.08**	**2.73E-05**	**1.03E-03**	**3,272.08**	**0.04**	**0.16**	**3,320.75**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-21. EW 1 and EW 2 Offshore Operations Emissions

Notes:

1. EW 1 and EW 2 will share marine vessels during offshore operations, and the emissions presented here are the combined total for both projects.
2. Non-transit activity durations were estimated based on the number of days of operation provided by the project.
3. Transit emissions are based on an assumed vessel speed of 5 knots for SOV battery-only operation (and 10 knots for all other vessel activities), and the following one-way travel distances:
   South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
   Battery power operation for SOV: when within 7.0 nm of SBMT
4. The number of transits for each vessel are based on the following assumptions:
   Bi-weekly round trips to/from port for the service operations vessel.
   120 annual round trips to/from port for each crew transfer vessels.
   One annual round trip for the survey vessel.
5. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
6. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
7. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
8. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
9. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the $PM_{2.5}$ or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
10. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
11. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-22. EW 1 Offshore Maintenance Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)
Heavy Lift Vessel		3	738 x 157 x 45 (35)					
Main Engines	4			5.02	7,657	Diesel	55,000	10,000
Main Engines	2			3.20	1,769	Diesel		
Emergency Engine	1			3.07	292	Diesel		
Tug 1 (every year)		N/A	127 x 36 x 19 (17)					
Main Engines	2			2.08	3,600	Diesel	10,000	10,000
Aux. Engines	2			2.06	95	Diesel		
Tug 2 (every year)		N/A	127 x 36 x 19 (17)					
Main Engines	2			2.08	3,600	Diesel	10,000	10,000
Aux. Engines	2			2.06	95	Diesel		
Cargo Barge (every year)		N/A	400 x 105 x 25				0	0
Inter-Array Cable Lay Vessel (every year)		1	313 x 71 x 29 (24)					
Main Engines	4			2.09	2,606	Diesel	15,000	15,000
Export Cable Lay Vessel (once per 10 yrs)		1	459 x 97 x 36 (24)					
Main Engines	6			1.31	3,003	Diesel	15,000	15,000
WTG Temporary Generators (once per 10 yrs)	16	N/A	N/A	257	201	Diesel	0	11,270
TOTALS								

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-22. EW 1 Offshore Maintenance Emissions

Vessels/Equipment	Assumed fuel density (kg/gal)	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Heavy Lift Vessel											
Main Engines	3.18	1	6	0	22	24	528	44%	8%	4,324	69,182
Main Engines		1	6	0	22	24	528	44%	8%		
Emergency Engine		0	0	0	0	0	0	0%	0%		
Tug 1 (every year)											
Main Engines	3.18	1	15	0	22	24	528	35%	35%	1,965	69,182
Aux. Engines		1	15	0	22	24	528	35%	35%		
Tug 2 (every year)											
Main Engines	3.18	1	15	0	22	24	528	35%	35%	1,965	69,182
Aux. Engines		1	15	0	22	24	528	35%	35%		
Cargo Barge (every year)											
	N/A	1	15	0	22	24	528	N/A	N/A	N/A	N/A
Inter-Array Cable Lay Vessel (every year)											
Main Engines	3.18	1	9	0	14	24	336	38%	38%	1,769	66,038
Export Cable Lay Vessel (once per 10 yrs)											
Main Engines	3.18	1	9	0	14	24	336	23%	23%	1,769	66,038
WTG Temporary Generators (once per 10 yrs)											
	3.18	0	0	0	6	24	144	0%	95%	0	21,264
TOTALS										**11,792**	**360,887**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-22. EW 1 Offshore Maintenance Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Heavy Lift Vessel													
Main Engines	2.22	2.74	5.28	0.20	0.18	0.42	0.18	2.27E-05	0.01	694.13	1.06E-02	0.03	703.53
Main Engines	0.04	0.72	0.61	0.02	0.02	7.62E-04	3.57E-03	2.07E-06	2.62E-05	82.92	1.22E-03	4.05E-03	84.16
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 1 (every year)													
Main Engines	0.46	8.22	5.55	0.30	0.29	6.93E-03	0.04	3.63E-05	2.38E-04	753.70	0.01	0.04	764.96
Aux. Engines	1.11E-02	0.20	0.15	5.85E-03	5.68E-03	1.83E-04	1.02E-03	7.10E-07	6.29E-06	19.89	2.40E-04	9.73E-04	20.19
Tug 2 (every year)													
Main Engines	0.46	8.22	5.55	0.30	0.29	6.93E-03	0.04	3.63E-05	2.38E-04	753.70	0.01	0.04	764.96
Aux. Engines	1.11E-02	0.20	0.15	5.85E-03	5.68E-03	1.83E-04	1.02E-03	7.10E-07	6.29E-06	19.89	2.40E-04	9.73E-04	20.19
Cargo Barge (every year)													
Inter-Array Cable Lay Vessel (every year)													
Main Engines	0.50	8.98	5.43	0.54	0.53	6.79E-03	0.05	6.59E-05	2.34E-04	738.43	0.01	0.04	749.46
Export Cable Lay Vessel (once per 10 yrs)													
Main Engines	0.59	14.91	1.24	0.21	0.19	0.45	0.05	2.42E-05	0.02	742.13	1.13E-02	0.03	752.17
WTG Temporary Generators (once per 10 yrs)													
	0.07	0.15	1.27	7.27E-03	7.05E-03	5.45E-04	5.60E-03	1.11E-06	1.88E-05	59.28	2.40E-03	4.81E-04	59.49
TOTALS	**4.36**	**44.33**	**25.22**	**1.59**	**1.52**	**0.90**	**0.38**	**1.90E-04**	**0.03**	**3,864.07**	**0.06**	**0.18**	**3,919.09**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:

HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-22. EW 1 Offshore Maintenance Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Heavy Lift Vessel													
Main Engines	0.14	0.17	0.33	1.23E-02	1.13E-02	0.03	1.15E-02	1.42E-06	9.10E-04	43.38	6.60E-04	1.91E-03	43.97
Main Engines	2.49E-03	0.04	0.04	1.07E-03	1.04E-03	4.76E-05	2.23E-04	1.29E-07	1.64E-06	5.18	7.63E-05	2.53E-04	5.26
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 1 (every year)													
Main Engines	0.01	0.23	0.16	8.51E-03	8.25E-03	1.97E-04	1.22E-03	1.03E-06	6.77E-06	21.41	3.15E-04	1.05E-03	21.73
Aux. Engines	3.15E-04	5.69E-03	4.16E-03	1.66E-04	1.61E-04	5.19E-06	2.89E-05	2.02E-08	1.79E-07	0.57	6.82E-06	2.76E-05	0.57
Tug 2 (every year)													
Main Engines	0.01	0.23	0.16	8.51E-03	8.25E-03	1.97E-04	1.22E-03	1.03E-06	6.77E-06	21.41	3.15E-04	1.05E-03	21.73
Aux. Engines	3.15E-04	5.69E-03	4.16E-03	1.66E-04	1.61E-04	5.19E-06	2.89E-05	2.02E-08	1.79E-07	0.57	6.82E-06	2.76E-05	0.57
Cargo Barge (every year)													
Inter-Array Cable Lay Vessel (every year)													
Main Engines	1.33E-02	0.24	0.15	1.46E-02	1.41E-02	1.82E-04	1.38E-03	1.76E-06	6.26E-06	19.78	2.91E-04	9.67E-04	20.07
Export Cable Lay Vessel (once per 10 yrs)													
Main Engines	0.02	0.40	0.03	5.65E-03	5.20E-03	1.21E-02	1.40E-03	6.50E-07	4.17E-04	19.88	3.02E-04	8.77E-04	20.15
WTG Temporary Generators (once per 10 yrs)	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**0.20**	**1.33**	**0.87**	**0.05**	**0.05**	**0.04**	**1.69E-02**	**6.07E-06**	**1.35E-03**	**132.18**	**1.97E-03**	**6.16E-03**	**134.06**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-22. EW 1 Offshore Maintenance Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 57 wind turbine locations for EW 1.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
   Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
3. The number of transits for each vessel are based on the following assumptions:
   One annual round trip each for heavy lift vessel, tugs and barge, and interarray cable lay vessel.
   One round trip every 10 years (estimated) for export cable lay vessel.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
6. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
8. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
9. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
10. WTG temporary blackout generators will be portable generators lifted onto WTG platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
11. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-23. EW 2 Offshore Maintenance Emissions

Vessels/Equipment	No. of Engines per vessel	1. DP 2.Anchored 3.Spuds	Dimensions (ft) length x width x depth (draft)	Emission Factor Used (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Transit assumed fuel rate (kg per vessel per day)	Non-Transit assumed fuel rate (kg per vessel per day)	Assumed fuel density (kg/gal)
Heavy Lift Vessel		3	738 x 157 x 45 (35)						
Main Engines	4			5.02	7,657	Diesel	55,000	10,000	3.18
Main Engines	2			3.20	1,769	Diesel			
Emergency Engine	1			3.07	292	Diesel			
Tug 1 (every year)		N/A	127 x 36 x 19 (17)						
Main Engines	2			2.08	3,600	Diesel	10,000	10,000	3.18
Aux. Engines	2			2.06	95	Diesel			
Tug 2 (every year)		N/A	127 x 36 x 19 (17)						
Main Engines	2			2.08	3,600	Diesel	10,000	10,000	3.18
Aux. Engines	2			2.06	95	Diesel			
Cargo Barge (every year)		N/A	400 x 105 x 25				0	0	N/A
Inter-Array Cable Lay Vessel (every year)		1	313 x 71 x 29 (24)						
Main Engines	4			2.09	2,606	Diesel	15,000	15,000	3.18
Export Cable Lay Vessel (once per 10 yrs)		1	459 x 97 x 36 (24)						
Main Engines	6			1.31	3,003	Diesel	15,000	15,000	3.18
WTG Temporary Generators (once per 10 yrs)	16	N/A	N/A	257	201	Diesel	0	11,270	3.18
TOTALS									

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-23. EW 2 Offshore Maintenance Emissions

Vessels/Equipment	Transit Round Trips	Transit Duration (hrs/round trip)	Non-OCS Operating Days	OCS Operating Days	Non-Transit Operating Hours (hrs/day)	Non-Transit Total Operating Time (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)
Heavy Lift Vessel										
Main Engines	1	6	0	37	24	888	44%	8%	4,324	116,352
Main Engines	1	6	0	37	24	888	44%	8%		
Emergency Engine	0	0	0	0	0	0	44%	8%		
Tug 1 (every year)										
Main Engines	1	15	0	37	24	888	35%	35%	1,965	116,352
Aux. Engines	1	15	0	37	24	888	35%	35%		
Tug 2 (every year)										
Main Engines	1	15	0	37	24	888	35%	35%	1,965	116,352
Aux. Engines	1	15	0	37	24	888	35%	35%		
Cargo Barge (every year)										
	1	15	0	37	24	888	N/A	N/A	N/A	N/A
Inter-Array Cable Lay Vessel (every year)										
Main Engines	1	9	0	28	24	672	38%	38%	1,769	132,075
Export Cable Lay Vessel (once per 10 yrs)										
Main Engines	1	9	0	14	24	336	23%	23%	1,769	66,038
WTG Temporary Generators (once per 10 yrs)										
	0	0	0	6	24	144	0%	95%	0	21,264
TOTALS									**11,792**	**568,434**

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-23. EW 2 Offshore Maintenance Emissions

	Total Emissions (Non-Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Heavy Lift Vessel													
Main Engines	3.74	4.61	8.88	0.33	0.31	0.71	0.31	3.81E-05	0.02	1,167.41	1.78E-02	0.05	1,183.20
Main Engines	0.07	1.21	1.03	0.03	0.03	1.28E-03	6.00E-03	3.48E-06	4.41E-05	139.45	2.05E-03	6.82E-03	141.54
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 1 (every year)													
Main Engines	0.77	13.82	9.33	0.50	0.49	1.17E-02	0.07	6.11E-05	4.01E-04	1,267.59	0.02	0.06	1,286.52
Aux. Engines	1.87E-02	0.34	0.25	9.85E-03	9.55E-03	3.07E-04	1.71E-03	1.19E-06	1.06E-05	33.45	4.04E-04	1.64E-03	33.95
Tug 2 (every year)													
Main Engines	0.77	13.82	9.33	0.50	0.49	1.17E-02	0.07	6.11E-05	4.01E-04	1,267.59	0.02	0.06	1,286.52
Aux. Engines	1.87E-02	0.34	0.25	9.85E-03	9.55E-03	3.07E-04	1.71E-03	1.19E-06	1.06E-05	33.45	4.04E-04	1.64E-03	33.95
Cargo Barge (every year)													
Inter-Array Cable Lay Vessel (every year)													
Main Engines	1.00	17.96	10.87	1.09	1.05	1.36E-02	0.10	1.32E-04	4.67E-04	1,476.85	0.02	0.07	1,498.92
Export Cable Lay Vessel (once per 10 yrs)													
Main Engines	0.59	14.91	1.24	0.21	0.19	0.45	0.05	2.42E-05	0.02	742.13	1.13E-02	0.03	752.17
WTG Temporary Generators (once per 10 yrs)													
	0.07	0.15	1.27	7.27E-03	7.05E-03	5.45E-04	5.60E-03	1.11E-06	1.88E-05	59.28	2.40E-03	4.81E-04	59.49
TOTALS	**7.04**	**67.16**	**42.44**	**2.69**	**2.58**	**1.20**	**0.62**	**3.23E-04**	**0.04**	**6,187.20**	**0.09**	**0.29**	**6,276.26**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Non-Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during non-transit activities
Time = Total non-transit activity duration, hours

For HAP, lead, and H2SO4:

HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-23. EW 2 Offshore Maintenance Emissions

	Total Emissions (Transit)												
Vessels/Equipment	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**Pb tons**	**H_2SO_4 tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Heavy Lift Vessel													
Main Engines	0.14	0.17	0.33	1.23E-02	1.13E-02	0.03	1.15E-02	1.42E-06	9.10E-04	43.38	6.60E-04	1.91E-03	43.97
Main Engines	2.49E-03	0.04	0.04	1.07E-03	1.04E-03	4.76E-05	2.23E-04	1.29E-07	1.64E-06	5.18	7.63E-05	2.53E-04	5.26
Emergency Engine	0	0	0	0	0	0	0	0	0	0	0	0	0
Tug 1 (every year)													
Main Engines	1.29E-02	0.23	0.16	8.51E-03	8.25E-03	1.97E-04	1.22E-03	1.03E-06	6.77E-06	21.41	3.15E-04	1.05E-03	21.73
Aux. Engines	3.15E-04	5.69E-03	4.16E-03	1.66E-04	1.61E-04	5.19E-06	2.89E-05	2.02E-08	1.79E-07	0.57	6.82E-06	2.76E-05	0.57
Tug 2 (every year)													
Main Engines	1.29E-02	0.23	0.16	8.51E-03	8.25E-03	1.97E-04	1.22E-03	1.03E-06	6.77E-06	21.41	3.15E-04	1.05E-03	21.73
Aux. Engines	3.15E-04	5.69E-03	4.16E-03	1.66E-04	1.61E-04	5.19E-06	2.89E-05	2.02E-08	1.79E-07	0.57	6.82E-06	2.76E-05	0.57
Cargo Barge (every year)													
Inter-Array Cable Lay Vessel (every year)													
Main Engines	1.33E-02	0.24	0.15	1.46E-02	1.41E-02	1.82E-04	1.38E-03	1.76E-06	6.26E-06	19.78	2.91E-04	9.67E-04	20.07
Export Cable Lay Vessel (once per 10 yrs)													
Main Engines	0.02	0.40	0.03	5.65E-03	5.20E-03	1.21E-02	1.40E-03	6.50E-07	4.17E-04	19.88	3.02E-04	8.77E-04	20.15
WTG Temporary Generators (once per 10 yrs)													
	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**0.20**	**1.33**	**0.87**	**0.05**	**0.05**	**0.04**	**1.69E-02**	**6.07E-06**	**1.35E-03**	**132.18**	**1.97E-03**	**6.16E-03**	**134.06**

For VOC, NOx, CO, PM10, PM2.5, SO2, CO2, CH4, N2O:

$$Transit\ tons\ = \frac{(N)\ *\ (hp)\ *\ (Load\ \%)\ *\ (Trips)\ *\ (Time)\ *\ (Emission\ factor, g/hp-hr)}{(453.6\ g\ per\ lb)*\ (2000\ lb\ per\ ton)}$$

Where:
N = Number of engines
hp = Engine horsepower rating
Load % = Average engine load during transit
Trips = number of round trip transits from port to the project area
Time = round trip duration per transit, hours

For HAP, lead, and H2SO4:
HAP = 0.0807 * (total VOC) + 0.0213 * (total PM2.5)
Lead = 0.000125 * (total PM2.5)
H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on Section 2.6 of 2009 ICF report.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-23. EW 2 Offshore Maintenance Emissions

Notes:

1. Emission calculations provided in this assessment are based on development of up to 90 wind turbine locations for EW 2.
2. Transit emissions are based on an assumed vessel speed of 6 knots for tugs and barges (and 10 knots for all other vessel types), and the following one-way travel distances:
   South Brooklyn Marine Terminal to center of OCS lease area: 43.5 nm (Kings: 7.8 nm; Queens: 3 nm; Monmouth: 2.7 nm; OCS radius: 30 nm)
   Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
3. The number of transits for each vessel are based on the following assumptions:
   One annual round trip each for heavy lift vessel, tugs and barge, and interarray cable lay vessel.
   One round trip every 10 years (estimated) for export cable lay vessel.
4. The specific vessels for each operation have not been finalized at this time; however, the vessels identifed for each installation activity are typical sizes for performing this effort.
5. Default emission factors for marine vessel engines are from the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
6. For vessels known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the April 2022 EPA guidance.
8. HAP and Pb emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the latest (2017) National Emissions Inventory (NEI); i.e., they are calculated as percentages of the $PM_{2.5}$ or VOC emissions from the CMVs. The HAP and Pb emissions for nonroad engines were based on EPA's AP-42 Volume 1, Chapters 3.3 and 3.4 for small and large diesel engines. (see HAP emission factor summary pages)
9. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
10. WTG temporary blackout generators will be portable generators lifted onto WTG platform; emissions based on nonroad factors in Table 1 of 40 CFR 1039.101, AP-42 Table 3.3-2 (HAPs), and 40 CFR 98 (GHGs).
11. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-24. EW 1 and EW 2 O+M Base - Operating Emissions

								Fuel Use	Emissions												
Construction Equipment	**Source Category**	**HP per unit**	**Fuel Type**	**Emiss. Factor ID**	**hrs per day**	**Load Factor**	**Total Equip. Months**	**gal**	**VOC tons**	**NO_X tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAP Tons**	**Pb Tons**	**H_2SO_4 Tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Land-based Nonroad Equip.																					
250T Shore crane	2270002045	400	diesel	93	4	43%	12	6,721	0.03	0.27	0.07	1.12E-02	1.08E-02	5.47E-04	7.99E-03	0	1.88E-05	101.40	2.60E-03	2.58E-03	102.23
5T Forklift	2270002057	115	diesel	94	8	59%	12	5,361	0.03	0.14	0.06	1.15E-02	1.11E-02	4.17E-04	6.32E-03	0	1.43E-05	80.87	2.15E-03	2.06E-03	81.54
Worker Commute																					
Light Commercial Truck		-	diesel	134	-	-	184	13,106	0.04	0.16	0.30	4.15E-03	3.82E-03	1.23E-03	6.66E-03	0	4.24E-05	147.50	0.03	9.11E-04	148.52
Passenger Truck		-	gasoline	135	-	-	122	6,845	0.03	0.03	0.51	1.33E-03	1.17E-03	9.50E-04	3.13E-03	0	3.27E-05	66.25	1.70E-03	1.62E-03	66.78
							Total	**32,033**	**0.13**	**0.59**	**0.93**	**0.03**	**0.03**	**3.15E-03**	**0.02**	**0**	**1.08E-04**	**396.02**	**0.04**	**7.17E-03**	**399.06**

Notes:

1. Equipment assumptions based on information provided by the project.
2. Calculations assume equipment is used 5 days/wk - i.e., 21 days/month.
3. Calculations conservatively assume that onroad vehicles travel approximately 50 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
4. Calculations conservatively assume workers average daily round trip commute is approximately 40 miles per day, since emission factors from the MOVES2014 model for onroad vehicles are based on miles traveled.
5. Nonroad emission factors for criteria pollutants and GHG were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2022.
6. Nonroad emission factors for HAPs were estimated using ERG, "Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory," Volume I - Methodology, October 7, 2003.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-25. EW 1 Offshore Substation Generator Emissions

Generator Engine Data

Generator Manufacturer	TBD	
Model	TBD	
Engine Type	TBD	
Rated engine output	kW	600
Rated engine output	bhp	804
Engine speed	rpm	1800
Fuel consumption at 100% load	gal/hr	40.2
Number of generators	engines	1
Annual operating hours per generator	hr/yr	2,000
Annual Fuel Usage per generator	gal/yr	80,429

Fuel Data

Fuel type	Ultra low sulfur diesel	
Fuel heat content	Btu/lb (LHV)	18,360
Fuel heat content	Btu/lb (HHV)	19,326
Fuel density	lb/gal	7.01
Fuel sulfur content	% weight	0.0015
Conversion factor	LHV/HHV	0.95

Tetra Tech assumptions/calculations

Engine load	%	100
Heat input rate	MMBtu/hr (HHV)	5.63

Engine Emission Factors

NOx	g/kWh	0.67
CO	g/kWh	3.5
VOC	g/kWh	0.20
PM/PM10	g/kWh	0.03
PM2.5	g/kWh	0.03
SO2	lb/MMBtu (HHV)	0.0016
HAP	lb/MMBtu (HHV)	0.0016
Pb	lb/MMBtu (HHV)	7.69E-07
H2SO4	lb/MMBtu (HHV)	5.34E-05
CO2	lb/MMBtu (HHV)	163.1
CH4	lb/MMBtu (HHV)	0.007
N2O	lb/MMBtu (HHV)	0.001

Engine Emission Estimates

NOx	lb/hr (per engine)	0.89
CO	lb/hr (per engine)	4.63
VOC	lb/hr (per engine)	0.27
PM10	lb/hr (per engine)	0.04
PM2.5	lb/hr (per engine)	0.04
SO2	lb/hr (per engine)	8.74E-03
HAP	lb/hr (per engine)	8.96E-03
Pb	lb/hr (per engine)	4.33E-06
H2SO4	lb/hr (per engine)	3.01E-04
CO2	lb/hr (per engine)	918.0
CH4	lb/hr (per engine)	3.72E-02
N2O	lb/hr (per engine)	7.45E-03
CO2e	lb/hr (per engine)	921.1

	Short Term Emissions (lb/hr per engine)	Annual Emissions (tons/yr per engine)
NOx	0.89	0.89
CO	4.63	4.63
VOC	0.27	0.27
PM10	0.04	0.04
PM2.5	0.04	0.04
SO2	8.74E-03	8.74E-03
HAP	8.96E-03	8.96E-03
Pb	4.33E-06	4.33E-06
H2SO4	3.01E-04	3.01E-04
CO2	918.0	918
CH4	0.04	0.04
N2O	7.45E-03	7.45E-03
CO2e	921.1	921

Notes:

1. Engine power rating is based on project assumption.
2. It is assumed that each engine may be used for both emergency and non-emergency purposes, for up to 2,000 hours per year.
3. Emission factors for NOx, CO, VOC, and PM are based on EPA Tier 4 final standards from Table 1 of 40 CFR 1039.101.
   For the hydrocarbon value expressed as NMHC, VOC is assumed to be equal to 1.07 times the NMHC value, based on the 2005 EPA guidance document, "Conversion Factors for Hydrocarbon Emission Components," EPA420-R-05-015, December 2005.
4. All particulate (PM) is assumed to be ≤ to 10 µm (PM10) and 97% of the PM is assumed to be smaller than 2.5 µm (PM2.5) based on US EPA Report Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition, No. NR-0009d, July 2010.
5. SO2 emission factor calculated from mass balance for 0.0015% by weight ULSD, assuming 100% conversion of fuel sulfur to SO2.
6. HAP and Pb emission factors based on EPA's AP-42 Volume 1, Chapter 3.4 for large diesel engines.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
8. Emission factors used to calculate emission rates for CO2 (73.96 kg/MMBtu), CH4 (0.003 kg/MMBtu) and N2O (0.0006 kg/MMBtu) were based on Tables C-1 and C-2 of 40 CFR Part 98 - Mandatory Greenhouse Gas Reporting, Subpart C - General Stationary Fuel Combustion Sources.
9. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-26. EW 2 Offshore Substation Generator Emissions

Generator Engine Data

Generator Manufacturer	TBD	
Model	TBD	
Engine Type	TBD	
Rated engine output	kW	600
Rated engine output	bhp	804
Engine speed	rpm	1800
Fuel consumption at 100% load	gal/hr	40.2
Number of generators	engines	1
Annual operating hours per generator	hr/yr	2,000
Annual Fuel Usage per generator	gal/yr	80,429

Fuel Data

Fuel type	Ultra low sulfur diesel	
Fuel heat content	Btu/lb (LHV)	18,360
Fuel heat content	Btu/lb (HHV)	19,326
Fuel density	lb/gal	7.01
Fuel sulfur content	% weight	0.0015
Conversion factor	LHV/HHV	0.95

Tetra Tech assumptions/calculations

Engine load	%	100
Heat input rate	MMBtu/hr (HHV)	5.63

Engine Emission Factors

NOx	g/kWh	0.67
CO	g/kWh	3.5
VOC	g/kWh	0.20
PM/PM10	g/kWh	0.03
PM2.5	g/kWh	0.03
SO2	lb/MMBtu (HHV)	0.0016
HAP	lb/MMBtu (HHV)	0.0016
Pb	lb/MMBtu (HHV)	7.69E-07
H2SO4	lb/MMBtu (HHV)	5.34E-05
CO2	lb/MMBtu (HHV)	163.1
CH4	lb/MMBtu (HHV)	0.007
N2O	lb/MMBtu (HHV)	0.001

Engine Emission Estimates

NOx	lb/hr (per engine)	0.89
CO	lb/hr (per engine)	4.63
VOC	lb/hr (per engine)	0.27
PM10	lb/hr (per engine)	0.04
PM2.5	lb/hr (per engine)	0.04
SO2	lb/hr (per engine)	8.74E-03
HAP	lb/hr (per engine)	8.96E-03
Pb	lb/hr (per engine)	4.33E-06
H2SO4	lb/hr (per engine)	3.01E-04
CO2	lb/hr (per engine)	918.0
CH4	lb/hr (per engine)	3.72E-02
N2O	lb/hr (per engine)	7.45E-03
CO2e	lb/hr (per engine)	921.1

	Short Term Emissions (lb/hr per engine)	Annual Emissions (tons/yr per engine)
NOx	0.89	0.89
CO	4.63	4.63
VOC	0.27	0.27
PM10	0.04	0.04
PM2.5	0.04	0.04
SO2	8.74E-03	8.74E-03
HAP	8.96E-03	8.96E-03
Pb	4.33E-06	4.33E-06
H2SO4	3.01E-04	3.01E-04
CO2	918.0	918
CH4	0.04	0.04
N2O	7.45E-03	7.45E-03
CO2e	921.1	921

Notes:

1. Engine power rating is based on project assumption.
2. It is assumed that each engine may be used for both emergency and non-emergency purposes, for up to 2,000 hours per year.
3. Emission factors for NOx, CO, VOC, and PM are based on EPA Tier 4 final standards from Table 1 of 40 CFR 1039.101.
   For the hydrocarbon value expressed as NMHC, VOC is assumed to be equal to 1.07 times the NMHC value, based on the 2005 EPA guidance document, "Conversion Factors for Hydrocarbon Emission Components," EPA420-R-05-015, December 2005.
4. All particulate (PM) is assumed to be ≤ to 10 µm (PM10) and 97% of the PM is assumed to be smaller than 2.5 µm (PM2.5) based on US EPA Report Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition, No. NR-0009d, July 2010.
5. SO2 emission factor calculated from mass balance for 0.0015% by weight ULSD, assuming 100% conversion of fuel sulfur to SO2.
6. HAP and Pb emission factors based on EPA's AP-42 Volume 1, Chapter 3.4 for large diesel engines.
7. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
8. Emission factors used to calculate emission rates for CO2 (73.96 kg/MMBtu), CH4 (0.003 kg/MMBtu) and N2O (0.0006 kg/MMBtu) were based on Tables C-1 and C-2 of 40 CFR Part 98 - Mandatory Greenhouse Gas Reporting, Subpart C - General Stationary Fuel Combustion Sources.
9. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-27. EW 1 Onshore Substation Generator Emissions

Generator Engine Data

Generator Manufacturer	TBD	
Model	TBD	
Engine Type	TBD	
Rated engine output	kW	600
Rated engine output	bhp	804
Engine speed	rpm	1800
Fuel consumption at 100% load	gal/hr	40.2
Number of generators	engines	1
Annual operating hours per generator	hr/yr	500
Annual Fuel Usage per generator	gal/yr	20,107

Fuel Data

Fuel type	Ultra low sulfur diesel	
Fuel heat content	Btu/lb (LHV)	18,360
Fuel heat content	Btu/lb (HHV)	19,326
Fuel density	lb/gal	7.01
Fuel sulfur content	% weight	0.0015
Conversion factor	LHV/HHV	0.95

Tetra Tech assumptions/calculations

Engine load	%	100
Heat input rate	MMBtu/hr (HHV)	5.63

Engine Emission Factors

NOx	g/kWh	6.08
CO	g/kWh	3.5
VOC	g/kWh	0.34
PM/PM10	g/kWh	0.20
PM2.5	g/kWh	0.19
SO2	lb/MMBtu (HHV)	0.0016
HAP	lb/MMBtu (HHV)	0.0016
Pb	lb/MMBtu (HHV)	7.69E-07
H2SO4	lb/MMBtu (HHV)	5.34E-05
CO2	lb/MMBtu (HHV)	163.1
CH4	lb/MMBtu (HHV)	0.007
N2O	lb/MMBtu (HHV)	0.001

Engine Emission Estimates

NOx	lb/hr (per engine)	8.0
CO	lb/hr (per engine)	4.6
VOC	lb/hr (per engine)	0.45
PM10	lb/hr (per engine)	0.26
PM2.5	lb/hr (per engine)	0.26
SO2	lb/hr (per engine)	8.74E-03
HAP	lb/hr (per engine)	8.96E-03
Pb	lb/hr (per engine)	4.33E-06
H2SO4	lb/hr (per engine)	3.01E-04
CO2	lb/hr (per engine)	918.0
CH4	lb/hr (per engine)	3.72E-02
N2O	lb/hr (per engine)	7.45E-03
CO2e	lb/hr (per engine)	921.1

	Short Term Emissions (lb/hr per engine)	Annual Emissions (tons/yr per engine)
NOx	8.04	2.01
CO	4.63	1.16
VOC	0.45	0.11
PM10	0.26	0.07
PM2.5	0.26	0.06
SO2	8.74E-03	2.18E-03
HAP	8.96E-03	2.24E-03
Pb	4.33E-06	1.08E-06
H2SO4	3.01E-04	7.52E-05
CO2	918.0	229
CH4	0.04	9.31E-03
N2O	7.45E-03	1.86E-03
CO2e	921.1	230

Notes:

1. Engine power rating is based on project assumption.
2. It is assumed that each engine will only be used for emergency purposes and limited to no more than 500 hours per year to include maintenance and testing.
3. Emission factors for NOx, CO, VOC, and PM are based on EPA Tier 2 standards from Table 1 of 40 CFR 89.112.
   For standards presented as a combined NOx+NMHC total, the NOx fraction is assumed to be 95% of the total, with the remainder as NMHC, based on the 2004 CARB guidance document, "Policy: CARB Emission Factors for CI Diesel Engines – Percent HC in Relation to NMHC + NOx," June 28, 2004.
   For the hydrocarbon value expressed as NMHC, VOC is assumed to be equal to 1.07 times the NMHC value, based on the 2005 EPA guidance document, "Conversion Factors for Hydrocarbon Emission Components," EPA420-R-05-015, December 2005.
5. All particulate (PM) is assumed to be ≤ to 10 µm (PM10) and 97% of the PM is assumed to be smaller than 2.5 µm (PM2.5) based on US EPA Report Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition, No. NR-0009d, July 2010.
6. SO2 emission factor calculated from mass balance for 0.0015% by weight ULSD, assuming 100% conversion of fuel sulfur to SO2.
7. HAP and Pb emission factors based on EPA's AP-42 Volume 1, Chapter 3.4 for large diesel engines.
8. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
9. Emission factors used to calculate emission rates for CO2 (73.96 kg/MMBtu), CH4 (0.003 kg/MMBtu) and N2O (0.0006 kg/MMBtu) were based on Tables C-1 and C-2 of 40 CFR Part 98 - Mandatory Greenhouse Gas Reporting, Subpart C - General Stationary Fuel Combustion Sources.
10. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-28. EW 2 Onshore Substation Generator Emissions

Generator Engine Data

Generator Manufacturer	TBD	
Model	TBD	
Engine Type	TBD	
Rated engine output	kW	600
Rated engine output	bhp	804
Engine speed	rpm	1800
Fuel consumption at 100% load	gal/hr	40.2
Number of generators	engines	1
Annual operating hours per generator	hr/yr	500
Annual Fuel Usage per generator	gal/yr	20,107

Fuel Data

Fuel type	Ultra low sulfur diesel	
Fuel heat content	Btu/lb (LHV)	18,360
Fuel heat content	Btu/lb (HHV)	19,326
Fuel density	lb/gal	7.01
Fuel sulfur content	% weight	0.0015
Conversion factor	LHV/HHV	0.95

Tetra Tech assumptions/calculations

Engine load	%	100
Heat input rate	MMBtu/hr (HHV)	5.63

Engine Emission Factors

NOx	g/kWh	6.08
CO	g/kWh	3.5
VOC	g/kWh	0.34
PM/PM10	g/kWh	0.20
PM2.5	g/kWh	0.19
SO2	lb/MMBtu (HHV)	0.0016
HAP	lb/MMBtu (HHV)	0.0016
Pb	lb/MMBtu (HHV)	7.69E-07
H2SO4	lb/MMBtu (HHV)	5.34E-05
CO2	lb/MMBtu (HHV)	163.1
CH4	lb/MMBtu (HHV)	0.007
N2O	lb/MMBtu (HHV)	0.001

Engine Emission Estimates

NOx	lb/hr (per engine)	8.0
CO	lb/hr (per engine)	4.6
VOC	lb/hr (per engine)	0.45
PM10	lb/hr (per engine)	0.26
PM2.5	lb/hr (per engine)	0.26
SO2	lb/hr (per engine)	8.74E-03
HAP	lb/hr (per engine)	8.96E-03
Pb	lb/hr (per engine)	4.33E-06
H2SO4	lb/hr (per engine)	3.01E-04
CO2	lb/hr (per engine)	918.0
CH4	lb/hr (per engine)	3.72E-02
N2O	lb/hr (per engine)	7.45E-03
CO2e	lb/hr (per engine)	921.1

	Short Term Emissions (lb/hr per engine)	Annual Emissions (tons/yr per engine)
NOx	8.04	2.01
CO	4.63	1.16
VOC	0.45	0.11
PM10	0.26	0.07
PM2.5	0.26	0.06
SO2	8.74E-03	2.18E-03
HAP	8.96E-03	2.24E-03
Pb	4.33E-06	1.08E-06
H2SO4	3.01E-04	7.52E-05
CO2	918.0	229
CH4	0.04	9.31E-03
N2O	7.45E-03	1.86E-03
CO2e	921.1	230

Notes:

1. Engine power rating is based on project assumption.
2. It is assumed that each engine will only be used for emergency purposes and limited to no more than 500 hours per year to include maintenance and testing.
3. Emission factors for NOx, CO, VOC, and PM are based on EPA Tier 2 standards from Table 1 of 40 CFR 89.112.
   For standards presented as a combined NOx+NMHC total, the NOx fraction is assumed to be 95% of the total, with the remainder as NMHC, based on the 2004 CARB guidance document, "Policy: CARB Emission Factors for CI Diesel Engines – Percent HC in Relation to NMHC + NOx," June 28, 2004.
   For the hydrocarbon value expressed as NMHC, VOC is assumed to be equal to 1.07 times the NMHC value, based on the 2005 EPA guidance document, "Conversion Factors for Hydrocarbon Emission Components," EPA420-R-05-015, December 2005.
5. All particulate (PM) is assumed to be ≤ to 10 µm (PM10) and 97% of the PM is assumed to be smaller than 2.5 µm (PM2.5) based on US EPA Report Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition, No. NR-0009d, July 2010.
6. SO2 emission factor calculated from mass balance for 0.0015% by weight ULSD, assuming 100% conversion of fuel sulfur to SO2.
7. HAP and Pb emission factors based on EPA's AP-42 Volume 1, Chapter 3.4 for large diesel engines.
9. H2SO4 emissions assume 2.247% conversion of fuel sulfur to sulfate, based on equations 3.3 and H.1 of the EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022.
9. Emission factors used to calculate emission rates for CO2 (73.96 kg/MMBtu), CH4 (0.003 kg/MMBtu) and N2O (0.0006 kg/MMBtu) were based on Tables C-1 and C-2 of 40 CFR Part 98 - Mandatory Greenhouse Gas Reporting, Subpart C - General Stationary Fuel Combustion Sources.
10. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-29. EW 1 and EW 2 Switchgear SF6 Emissions

Circuit Breaker SF_6 [1] Fugitive Emissions		EW 1 Offshore Substation	EW 2 Offshore Substation	EW 1 Wind Turbines	EW 2 Wind Turbines	EW 1 Onshore Substation	EW 2 Onshore Substation
Total SF_6 Storage Capacity (245kV/362kV switches)[2]	kg	800	2,885	N/A	N/A	4,400	11,311
Total SF_6 Storage Capacity (72.5kV/145kV switches)[2]	kg	725	2,754	18.0	18.0	N/A	N/A
Total SF_6 Storage Capacity (13.8 kV Switches)[2]	kg	14.2	14.2	N/A	N/A	10.8	10.8
Total SF_6 Storage Capacity (Gas-Insulated Duct Bus)[2]	kg	N/A	1,433	N/A	N/A	N/A	N/A
Number of Locations	units	1	1	57	90	1	1
SF_6 Leak Rate, Higher-Voltage Switches (by weight) [3]	% per year	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
SF_6 Leak Rate, 13.8 kV Switches (by weight) [4]	% per year	0.1%	0.1%	N/A	N/A	0.1%	0.1%
SF_6 Leak Rate, Gas-Insulated Duct Bus (by weight) [3]	% per year	N/A	0.5%	N/A	N/A	N/A	N/A
SF_6 Emissions	lbs/year	16.84	77.98	11.31	17.86	48.53	124.71
SF_6 Emissions	tons/year	0.0084	0.0390	0.0057	0.0089	0.0243	0.0624
Annual GHG emissions (CO_2e) [5]	tons/year	191.99	888.99	128.93	203.57	553.19	1,421.64

1. SF_6 = Sulfur Hexafluoride
2. Storage capacity based on estimates provided by the project. (All capacities shown include a 20% design margin.)
3. Leak rate for higher-voltage switches is based on the International Electrotechnical Commission Standard 62271-1, 2004, as presented in the U.S. EPA technical paper, "SF6 Leak Rates from High Voltage Circuit Breakers - U.S. EPA Investigates Potential Greenhouse Gas Emissions Source."
4. Leak rate for 13.8 kV switches is based on information provided by the project.
5. CO_2e emission rates use the following carbon equivalence factors:

   For SF_6: 22,800 (based on Table A-1 to Subpart A of 40 CFR Part 98—Global Warming Potentials)

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS

Table K-1-30. EW 1 and EW 2 Fugitive Emissions

Painting Fugitive Emissions (Construction, Commissioning, and O&M)		EW 1 Offshore Substation	EW 2 Offshore Substation	EW 1 Wind Turbines	EW 2 Wind Turbines
Annual paint use	liters	60	60	300	300
Paint density	g/cm3	1.51	1.51	1.51	1.51
Paint VOC content	g/L	216	216	216	216
Methyl-n-amyl ketone (non-HAP)	% wt.	2.5	2.5	2.5	2.5
Toluene (HAP)	% wt.	1.0	1.0	1.0	1.0
Annual VOC emissions	lb/year	28.6	28.6	142.9	142.9
Annual VOC emissions	tons/year	0.014	0.014	0.071	0.071
Annual HAP emissions	lb/year	2.0	2.0	10.0	10.0
Annual HAP emissions	tons/year	9.99E-04	9.99E-04	4.99E-03	4.99E-03

1. Paint usage based on project estimates.
2. Paint composition based on representative data for Carboxane 2000 marine paint, product ID 2000A1NL.

Fuel Oil Storage Tank Fugitive Emissions (Construction, Commissioning, and O&M)		EW 1 Offshore Substation	EW 2 Offshore Substation
Fuel oil storage tank contents		USLD	ULSD
Fuel oil storage tank capacity	gallons	7,925	7,925
Annual throughput	gallons	80,429	80,429
Benzene (HAP)	% wt.	0.1	0.1
Cumene (HAP)	% wt.	1.0	1.0
Ethylbenzene (HAP)	% wt.	1.0	1.0
n-Hexane (HAP)	% wt.	1.0	1.0
Naphthalene (HAP)	% wt.	2.0	2.0
Toluene (HAP)	% wt.	1.0	1.0
Xylenes (HAP)	% wt.	1.0	1.0
Total HAP	% wt.	7.1	7.1
Annual VOC emissions	lb/year	2.5	2.5
Annual VOC emissions	tons/year	1.25E-03	1.25E-03
Annual HAP emissions	lb/year	0.18	0.18
Annual HAP emissions	tons/year	8.88E-05	8.88E-05

1. VOC emissions estimate calculated in TANKS 4.0.9d with estimated storage tank dimensions, using meteorological conditions for New York, NY.
2. HAP composition based on representative data from MSDS for Gulf ULSD.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-31. Emission Factors

Commercial Marine Vessels (CMVs)

		Commercial Marine Vessel Emission Factors (g/hp-hr) /a, /b, /c, /d, /e, /f									Fuel Cons.
	Engine Type	VOC	NO_x	CO	PM/ PM_{10} /g	$PM_{2.5}$ /g	SO_2 /h	CO_2	CH_4	N_2O	(gal/hp-hr) /i
1.11	EPA default, Cat 1, Tier 1/2, kW ≥ 37, all displacement ranges (propulsion)	0.32	7.31	1.34	0.32	0.31	0.0047	507	0.0061	0.0248	0.050
1.12	EPA default, Cat 1, Tier 1/2, kW ≥ 37, all displacement ranges (auxiliary)	0.32	7.31	1.34	0.54	0.53	0.0047	507	0.0061	0.0248	0.050
1.21	EPA default, Cat 2, Tier 1/2, all kW ranges, all displacement ranges (all)	0.11	7.87	1.85	0.23	0.22	0.0047	507	0.0020	0.0248	0.050
1.31	EPA default, Cat 3, 1999 and earlier, MSD engines, MGO/MDO fuel (propulsion	0.39	9.85	0.82	0.14	0.13	0.299	490	0.0075	0.0216	0.048
1.32	EPA default, Cat 3, 1999 and earlier, MSD engines, MGO/MDO fuel (auxiliary)	0.31	10.29	0.82	0.14	0.13	0.316	519	0.0060	0.0216	0.051
2.03	EPA Tier 2 - Cat 1 (19 ≤ kW < 37, 2004+)	0.30	5.32	4.10	0.45	0.43	0.0047	507	0.0061	0.0248	0.050
2.04	EPA Tier 2 - Cat 1 (disp < 0.9; kW ≥ 37, 2005+)	0.29	5.32	3.73	0.30	0.29	0.0047	507	0.0061	0.0248	0.050
2.05	EPA Tier 2 - Cat 1 (0.9 ≤ disp < 1.2; kW = all 2004+)	0.28	5.10	3.73	0.22	0.22	0.0047	507	0.0061	0.0248	0.050
2.06	EPA Tier 2 - Cat 1 (1.2 ≤ disp < 2.5; kW = all, 2004+)	0.28	5.10	3.73	0.15	0.14	0.0047	507	0.0061	0.0248	0.050
2.07	EPA Tier 2 - Cat 1 (2.5 ≤ disp < 5.0; kW = all, 2007+)	0.28	5.10	3.73	0.15	0.14	0.0047	507	0.0061	0.0248	0.050
2.08	EPA Tier 2 - Cat 2 (5 ≤ disp < 15; kW = all, 2007+)	0.31	5.53	3.73	0.20	0.20	0.0047	507	0.0075	0.0248	0.050
2.09	EPA Tier 2 - Cat 2 (15 ≤ disp < 20; kW < 3300, 2007+)	0.34	6.17	3.73	0.37	0.36	0.0047	507	0.0075	0.0248	0.050
2.10	EPA Tier 2 - Cat 2 (15 ≤ disp < 20; kW ≥ 3300, 2007+)	0.38	6.95	3.73	0.37	0.36	0.0047	507	0.0075	0.0248	0.050
3.03	EPA Tier 3 - Cat 1 < 3700 kW (disp < 0.9; 19 ≤ kW < 75, 2014+)	0.18	3.33	3.73	0.22	0.22	0.0047	507	0.0061	0.0248	0.050
3.07	EPA Tier 3 - Cat 1 < 3700 kW (kW/L ≤ 35; 1.2 ≤ disp < 2.5; kW < 600; 2018+)	0.22	3.97	3.73	0.07	0.07	0.0047	507	0.0061	0.0248	0.050
3.08	EPA Tier 3 - Cat 1 < 3700 kW (kW/L ≤ 35; 1.2 ≤ disp < 2.5; kW ≥ 600)	0.22	3.97	3.73	0.08	0.08	0.0047	507	0.0061	0.0248	0.050
3.20	EPA Tier 3 - Cat 2 < 3700 kW (kW/L > 35; 7.0 ≤ disp < 15.0; kW < 2000)	0.24	4.39	3.73	0.10	0.10	0.0047	507	0.0075	0.0248	0.050
4.02	EPA Tier 4 - Cat 1/Cat 2 > 600 kW (1400 ≤ kW < 2000)	0.15	1.34	3.73	0.03	0.03	0.0047	507	0.0061	0.0248	0.050
5.02	MARPOL/EPA Tier 3 (Category 3 engines 2016+)	1.57	1.94	3.73	0.14	0.13	0.299	490	0.007	0.022	0.048

/a Default emission factors for NOx, VOC, CO, PM10, PM2.5, SO2, CO2, and CH4 from Category 1 and Category 2 engines (when age is unknown) are based on the worst case of either the Tier 1 or Tier 2 values in the following sections of the 2022 EPA guidance document, "Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions," EPA-420-B-22-011, April 2022:
Table H.1 for NOx; Table H.2 for PM10 and PM2.5; Table H.3 for VOC and CH4; Table H.4 for CO; Table H.7 for SO2 and CO2; and Equation 4.3 for N2O.

/b Emission factors for Category 3 engines are based on the values for 1999 and earlier engines in the following sections of the 2022 EPA guidance:
Table 3.5 for NOx; Equation 3.3 for PM10; Table 3.8 for VOC, CO, and CH4; Equation 3.4 for CO2; Equation 3.5 for SO2; and Table 3.9 for N2O.
Brake specific fuel consumption (BSFC) for Category 3 engines is from Table 3.6 of the 2022 EPA guidance.
PM2.5 for Category 3 engines is assumed to be 92% of the PM10 value, based on section 3.5.3 of the 2022 EPA guidance.

/c For Category 1 or 2 engines known to be subject to EPA Tier 2, Tier 3, or Tier 4, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, HC, and PM, based on the engine's power rating, displacement, and model year.

/d For Category 3 engines known to be subject to MARPOL and/or EPA Tier 2 or 3, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, and HC. An engine speed of 500 rpm was assumed for all Category 3 engines.
For PM, the value for Category 3 propulsion engines in the 2022 EPA guidance was used, since EPA has not established a PM standard for Category 3 engines.

/e For Category 3 engines known to be subject to MARPOL and/or EPA Tier 2 or 3, the appropriate emission standards from 40 CFR 1042 may be used for NOx, CO, and HC. An engine speed of 500 rpm was assumed for all Category 3 engines.
For PM, the 2022 EPA guidance factor for Category 3 engines was used, since EPA has not established a PM standard for Category 3 engines.

/f For standards in 40 CFR 1042 presented as a combined NOx+HC total, NMHC+NOx total, or NOx+THC total, the NOx fraction is assumed to be 95% of the total, with the remainder as HC, NMHC, or THC respectively, based on the 2004 CARB guidance document, "Policy: CARB Emission Factors for CI Diesel Engines – Percent HC in Relation to NMHC + NOx," June 28, 2004.
For all hydrocarbon values expressed as either HC, THC, or NMHC, VOC is assumed to be equal to 1.053 times the HC or THC value, and NMHC is assumed to be 0.984 times the HC or THC value, based on the 2005 EPA guidance document, "Conversion Factors for Hydrocarbon Emission Components," EPA420-R-05-015, December 2005. VOC is accordingly assumed to be (1.053/0.984) = 1.07 times the NMHC value.

/g All PM is assumed to less than 10 µm in diameter; therefore, PM emission factor is equivalent to PM_{10} emission factor. For Category 1 and 2 engines, $PM_{2.5}$ is estimated to be 97 % of $PM_{10,}$ per section 4.5.3 of the 2022 EPA guidance; for Category 3 engines, PM2.5 is assumed to be 92% of PM10, per section 3.5.3 of the 2022 EPA guidance.

/h SO2 emission factors assume a fuel sulfur content of: 0.0015 percent by weight for Category 1 and 2 engines (Table H.7 of 2022 EPA guidance); and 0.1 percent by weight for Category 3 engines (Equation 3.5 of 2022 EPA guidance).

/i Fuel consumption for Category 1 and 2 marine engines was based on the brake specific fuel consumption (BSFC) value provided in section 4.5.2 of the 2022 EPA guidance for engines ≥ 37 kW, with an assumed fuel density of 3.18 kg/gallon.
Fuel consumption for Category 3 marine engines was based on the BSFC values (g/kW-hr) provided in the 2022 EPA guidance, with an assumed fuel density of 3.18 kg/gallon.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-31. Emission Factors

Land-based Nonroad Engines and Other Equipment (Kings County, NY)

	NONROAD Source Category			NONROAD Emission Factors (g/hp-hr) /a								Climate Leaders (g/kWh) /b	Fuel Consumption gal/kWh /c	NONROAD
	SCC	Description	Engine Size (hp)	Exhaust+ Crankcase VOC	Exhaust NO_x	Exhaust CO	Exhaust PM_{10}	Exhaust $PM_{2.5}$	Exhaust SO_2	Exhaust CO_2	Exhaust CH_4	Exhaust N_2O		Default Load Factor
	Construction & Mining Subcategory (*002*)													
90	2270002027	Diesel Signal Boards/Light Plants	16 < hp <= 25	0.4998279	4.4688214	2.34746	0.34672598	0.336324	0.0039702	588.93769	0.0434024	0.015	0.058	43%
91	2270002033	Diesel Bore/Drill Rigs	175 < HP <= 300	0.25	2.42	0.58	0.12	0.12	0.003	530	0.014	0.014	0.052	43%
92	2270002036	Diesel Excavators	175 < HP <= 300	0.16	0.37	0.14	0.01	0.01	0.003	536	0.013	0.014	0.053	59%
93	2270002045	Diesel Cranes	300 < HP <= 600	0.17	1.40	0.38	0.06	0.06	0.003	531	0.014	0.014	0.052	43%
94	2270002057	Diesel Rough Terrain Forklifts	100 < hp <= 175	0.17	0.90	0.38	0.08	0.07	0.003	536	0.014	0.014	0.053	59%
95	2270002060	Diesel Rubber Tire Loaders	175 < hp <= 300	0.16	0.65	0.21	0.03	0.03	0.003	536	0.013	0.014	0.053	59%
96	2270002069	Diesel Crawler Tractor/Dozers	750 < hp <= 1000	0.21	2.74	0.60	0.07	0.07	0.003	536	0.017	0.014	0.053	59%
97	2270002075	Diesel Off-Highway Tractor	300 < HP <= 600	0.16	1.07	0.43	0.06	0.06	0.003	536	0.014	0.014	0.053	59%
98	2270002081	Diesel Other Construction Equip.	100 < hp <= 175	0.18	1.07	0.45	0.10	0.09	0.003	536	0.015	0.014	0.053	59%
	Industrial Equipment Subcategory (*003*)													
99	2270003010	Diesel Aerial Lifts	16 < hp <= 25	1.24	5.36	5.02	0.69	0.67	0.005	692	0.043	0.018	0.068	21%
	Commercial Equipment Subcategory (*006*)													
100	2270006005	Diesel Generator Sets	100 < HP <= 175	0.28	2.61	0.72	0.16	0.15	0.003	530	0.015	0.014	0.052	43%
101	2270006010	Diesel Pumps	300 < HP <= 600	0.22	2.46	0.70	0.10	0.10	0.003	530	0.013	0.014	0.052	43%
102	2270006015	Diesel Air Compressors	100 < HP <= 175	0.18	1.07	0.30	0.07	0.07	0.003	531	0.014	0.014	0.052	43%
103	2270006025	Diesel Welders	50 < hp <= 75	0.67	4.25	3.52	0.47	0.46	0.004	694	0.024	0.018	0.068	21%

/a Emission factors for the land-based nonroad engines were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2022.

/b Emission factors for N_2O are based on Table B-8 of the EPA report, "Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance," EPA430-K-16-004, January 2016. (0.57 g CH4/gal fuel and 0.26 g N2O/gal fuel, respectively)

/c Fuel consumption for each type of equipment was estimated based on CO2 emission factor (g/hp-hr) generated from the MOVES2014b model and the emission factor for the mass of CO2 generated per gallon of fuel (10.21 kg CO_2/gal fuel) as presented in Table A-1 of the EPA report, "Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance," EPA430-K-16-004, January 2016.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-31. Emission Factors

Land-based Nonroad Engines and Other Equipment (Nassau County, NY)

	NONROAD Source Category			NONROAD Emission Factors (g/hp-hr) /a								Climate Leaders (g/kWh) /b	Fuel Consumption gal/kWh /c	NONROAD
	SCC	Description	Engine Size (hp)	Exhaust+ Crankcase VOC	Exhaust NO_x	Exhaust CO	Exhaust PM_{10}	Exhaust $PM_{2.5}$	Exhaust SO_2	Exhaust CO_2	Exhaust CH_4	Exhaust N_2O		Default Load Factor
	Construction & Mining Subcategory (*002*)													
110	2270002027	Diesel Signal Boards/Light Plants	16 < hp <= 25	0.4998275	4.4688272	2.347462	0.34672634	0.3363244	0.0039702	588.93813	0.0434024	0.015	0.058	43%
111	2270002033	Diesel Bore/Drill Rigs	175 < HP <= 300	0.25	2.42	0.58	0.12	0.12	0.003	530	0.014	0.014	0.052	43%
112	2270002036	Diesel Excavators	175 < HP <= 300	0.16	0.37	0.14	0.01	0.01	0.003	536	0.013	0.014	0.053	59%
113	2270002045	Diesel Cranes	300 < HP <= 600	0.17	1.40	0.38	0.06	0.06	0.003	531	0.014	0.014	0.052	43%
114	2270002057	Diesel Rough Terrain Forklifts	100 < hp <= 175	0.17	0.90	0.38	0.08	0.07	0.003	536	0.014	0.014	0.053	59%
115	2270002060	Diesel Rubber Tire Loaders	175 < hp <= 300	0.16	0.65	0.21	0.03	0.03	0.003	536	0.013	0.014	0.053	59%
116	2270002069	Diesel Crawler Tractor/Dozers	750 < hp <= 1000	0.21	2.74	0.60	0.07	0.07	0.003	536	0.017	0.014	0.053	59%
117	2270002075	Diesel Off-Highway Tractor	300 < HP <= 600	0.16	1.07	0.43	0.06	0.06	0.003	536	0.014	0.014	0.053	59%
118	2270002081	Diesel Other Construction Equip.	100 < hp <= 175	0.18	1.07	0.45	0.10	0.09	0.003	536	0.015	0.014	0.053	59%
	Industrial Equipment Subcategory (*003*)													
119	2270003010	Diesel Aerial Lifts	16 < hp <= 25	1.24	5.36	5.02	0.69	0.67	0.005	692	0.043	0.018	0.068	21%
	Commercial Equipment Subcategory (*006*)													
120	2270006005	Diesel Generator Sets	100 < HP <= 175	0.28	2.61	0.72	0.16	0.15	0.003	530	0.015	0.014	0.052	43%
121	2270006010	Diesel Pumps	300 < HP <= 600	0.22	2.46	0.70	0.10	0.10	0.003	530	0.013	0.014	0.052	43%
122	2270006015	Diesel Air Compressors	100 < HP <= 175	0.18	1.07	0.30	0.07	0.07	0.003	531	0.014	0.014	0.052	43%
123	2270006025	Diesel Welders	50 < hp <= 75	0.67	4.25	3.52	0.47	0.46	0.004	694	0.024	0.018	0.068	21%

/a Emission factors for the land-based nonroad engines were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2022.

/b Emission factors for N_2O are based on Table B-8 of the EPA report, "Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance," EPA430-K-16-004, January 2016. (0.57 g CH4/gal fuel and 0.26 g N2O/gal fuel, respectively)

/c Fuel consumption for each type of equipment was estimated based on CO2 emission factor (g/hp-hr) generated from the MOVES2014b model and the emission factor for the mass of CO2 generated per gallon of fuel (10.21 kg CO_2/gal fuel) as presented in Table A-1 of the EPA report, "Direct Emissions from Mobile Combustion Sources, U.S. EPA Center for Corporate Leadership – Greenhouse Gas Inventory Guidance," EPA430-K-16-004, January 2016.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-31. Emission Factors

On-road Vehicles (Kings County, NY)

			MOVES2014b Emission factors in lb/VMT /a											
			VOC	NO_x	CO	PM_{10}	PM2.5	SO_2	HAP	CO_2	CH_4	N_2O	CO2e	mi/gal
131	Diesel Single Unit Short-haul Truck		0.00101	0.00759	0.00362	0.00029	0.00026	0.00004	0.00013	4.47360	0.00043	0.00002	4.48575	5.03
132	Diesel Refuse Truck		0.00048	0.00686	0.00249	0.00021	0.00019	0.00005	0.00007	5.68676	0.00031	0.00002	5.69804	3.96
133	Diesel Light Commercial Truck		0.00091	0.00311	0.00771	0.00011	0.00010	0.00002	0.00012	1.98729	0.00041	0.00001	1.99466	11.33
134	Diesel Passenger Truck		0.00048	0.00210	0.00385	0.00005	0.00005	0.00002	0.00009	1.90868	0.00038	0.00001	1.91577	11.79
135	Gasoline Passenger Truck		0.00064	0.00055	0.00986	0.00003	0.00002	0.00002	0.00006	1.29294	0.00003	0.00003	1.30114	14.97

/a Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014 model and inputs for calendar year 2022 using the latest input files for calendar year 2020 from the New York State Department of Environmental Conservation.

On-road Vehicles (Nassau County, NY)

			MOVES2014b Emission factors in lb/VMT /a											
			VOC	NO_x	CO	PM_{10}	PM2.5	SO_2	HAP	CO_2	CH_4	N_2O	CO2e	mi/gal
141	Diesel Single Unit Short-haul Truck		0.00087	0.00602	0.00329	0.00025	0.00023	0.00002	0.00010	2.84028	0.00030	0.00001	2.84685	7.92
142	Diesel Refuse Truck		0.00075	0.01157	0.00379	0.00051	0.00047	0.00004	0.00008	4.38876	0.00018	0.00001	4.39449	5.13
143	Diesel Light Commercial Truck		0.00154	0.00428	0.01240	0.00016	0.00015	0.00001	0.00017	1.60958	0.00039	0.00001	1.61536	13.98
144	Diesel Passenger Truck		0.00059	0.00184	0.00398	0.00005	0.00005	0.00001	0.00009	1.38976	0.00032	0.00001	1.39405	16.20
145	Gasoline Passenger Truck		0.00064	0.00064	0.00983	0.00003	0.00002	0.00001	0.00006	0.93536	0.00003	0.00003	0.94460	20.69

/a Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014 model and inputs for calendar year 2022 using the latest input files for calendar year 2020 from the New York State Department of Environmental Conservation.

Helicopters

			Emission Factors (lb/hr) /a									
	Helicopter Type	Default Speed (mph)	VOC	NO_x	CO	PM/PM10	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	Fuel Use (gal/hr)
161	Single	157.5	1.89	2.32	0.07	0.07	0.07	0.3	956.92	0.03	0.03	45.36
162	Twin Light	177	4.3	3.1	0.10	0.09	0.09	0.5	1589.69	0.04	0.05	75.35
163	Twin Medium	182.6	3.5	7.2	0.20	0.20	0.20	0.78	2459.92	0.1	0.1	116.59
164	Twin Heavy	188.2	2.67	34.66	0.82	0.80	0.80	2.11	6640.46	0.19	0.22	314.74

/a Emission factors for VOC, NOx, CO, PM, SO2, CO2, CH4, and N2O are from "BOEM Offshore Wind Energy Facilities Emission Estimating Tool - Technical Documentation,"OCS Study BOEM 2017-079, August 1, 2017 (https://www.boem.gov/Technical-Documentation-stakeholder/). Table 4 in this document provides default emission factors and gal/hr fuel consumption rates based on helicopter type. Table 9 provides default speeds based on helicopter type.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2) - AIR EMISSION CALCULATIONS
Table K-1-31. Emission Factors

Stationary Diesel Engines, Excluding Fire Pumps (<= 2,237 kW and Displacement < 10 L/cylinder)

			Subpart IIII standards (g/kWh) /a				(g/kWh) /b	Other Emission Factors (lb/MMBtu) /c, /d				Fuel Cons.
	Stationary Source Category	Engine Size (kW)	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	(gal/kWh) /e
254	Non-Emergency Engines Subject to Tier 4 Standards (2015 model year and later)	kW < 19	0.40	7.13	6.6	0.40	0.39	0.0015	163.1	0.007	0.001	0.067
255		19 <= kW < 56	0.25	4.47	5.0	0.03	0.03	0.0015	163.1	0.007	0.001	0.067
256		56 <= kW < 130	0.20	0.40	5.0	0.02	0.02	0.0015	163.1	0.007	0.001	0.067
257		130 <= kW <= 560	0.20	0.40	3.5	0.02	0.02	0.0015	163.1	0.007	0.001	0.067
258	Gensets	kW > 560	0.20	0.67	3.5	0.03	0.03	0.0015	163.1	0.007	0.001	0.067
259	All except gensets		0.20	3.5	3.5	0.04	0.04	0.0015	163.1	0.007	0.001	0.067

/a Values are from Table 1 of 40 CFR 1039.101, except as follows:
For standards presented as a combined NOx+NMHC total, the NOx fraction is assumed to be 95% of the total, with the remainder as NMHC, based on the 2004 CARB guidance document, "Policy: CARB Emission Factors for CI Diesel Engines – Percent HC in Relation to NMHC + NOx," June 28, 2004.
For all hydrocarbon values expressed as NMHC, VOC is assumed to be equal to 1.07 times the NMHC value, based on the 2005 EPA guidance document, "Conversion Factors for Hydrocarbon Emission Components," EPA420-R-05-015, December 2005.

/b All PM is assumed to less than 10 µm in diameter; therefore, PM emission factor is equivalent to PM_{10} emission factor. $PM_{2.5}$ is estimated to be 97 % of PM_{10} per EPA guidance in "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition," EPA420-R-10-018/NR-009d, July 2010.

/c SO2 emission factor based on typical mass balance for 0.0015% by weight ULSD, assuming 100% conversion of fuel sulfur to SO2.

/d Emission factors used to calculate emission rates for CO2 (73.96 kg/MMBtu), CH4 (0.003 kg/MMBtu) and N2O (0.0006 kg/MMBtu) were based on Tables C-1 and C-2 of 40 CFR Part 98 - Mandatory Greenhouse Gas Reporting, Subpart C - General Stationary Fuel Combustion Sources.

/e Fuel consumption rate is on a higher heating value (HHV) basis per unit of engine output, assuming the AP-42 specific consumption rate of 7,000 Btu/hp-hr, and a fuel heat content of 140,000 Btu/gal.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2)

Table K-1-32. MOVES Emission Factor Summary

Kings County, NY												
Input Year	Fuel	Vehicle Type	Emission Factor lbs/VMT										
			VOC	NOx	CO	PM10	PM2.5	SO2	HAPS	CO2	CH4	N2O	CO2e
2022	Diesel	Combination Long-haul Truck	0.00124	0.01452	0.00438	0.00052	0.00048	0.00005	0.00017	6.26592	0.00061	0.00001	6.28520
		Combination Short-haul Truck	0.00066	0.00840	0.00274	0.00030	0.00027	0.00005	0.00009	5.92943	0.00031	0.00002	5.94088
		Single Unit Long-haul Truck	0.00061	0.00568	0.00252	0.00017	0.00015	0.00004	0.00009	4.45192	0.00036	0.00002	4.46429
		Single Unit Short-haul Truck	0.00101	0.00759	0.00362	0.00029	0.00026	0.00004	0.00013	4.47360	0.00043	0.00002	4.48575
		Refuse Truck	0.00048	0.00686	0.00249	0.00021	0.00019	0.00005	0.00007	5.68676	0.00031	0.00002	5.69804
		Light Commercial Truck	0.00091	0.00311	0.00771	0.00011	0.00010	0.00002	0.00012	1.98729	0.00041	0.00001	1.99466
		Passenger Truck	0.00048	0.00210	0.00385	0.00005	0.00005	0.00002	0.00009	1.90868	0.00038	0.00001	1.91577
		Passenger Car	0.00042	0.00023	0.00448	0.00001	0.00001	0.00001	0.00007	0.88278	0.00033	0.00000	0.88534
	Gasoline	Combination Short-haul Truck	0.00294	0.00459	0.04556	0.00008	0.00007	0.00008	0.00031	5.68020	0.00003	0.00003	5.69062
		Single Unit Long-haul Truck	0.00213	0.00358	0.04945	0.00005	0.00004	0.00006	0.00021	3.85693	0.00005	0.00006	3.87547
		Single Unit Short-haul Truck	0.00161	0.00295	0.04627	0.00004	0.00003	0.00006	0.00016	3.86101	0.00006	0.00006	3.87888
		Refuse Truck	0.00340	0.00494	0.04550	0.00010	0.00009	0.00008	0.00036	5.50689	0.00007	0.00006	5.52320
		Light Commercial Truck	0.00059	0.00053	0.00920	0.00002	0.00002	0.00002	0.00006	1.31347	0.00004	0.00003	1.32221
		Passenger Truck	0.00064	0.00055	0.00986	0.00003	0.00002	0.00002	0.00006	1.29294	0.00003	0.00003	1.30114
		Passenger Car	0.00086	0.00054	0.00983	0.00003	0.00003	0.00001	0.00009	1.02051	0.00003	0.00003	1.02738

Note: Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014 model and inputs for calendar year 2022 using the latest input files for calendar year 2020 from the New York State Department of Environmental Conservation.

Nassau County, NY												
Input Year	Fuel	Vehicle Type	Emission Factor lbs/VMT										
			VOC	NOx	CO	PM10	PM2.5	SO2	HAPS	CO2	CH4	N2O	CO2e
2022	Diesel	Combination Long-haul Truck	0.00103	0.01212	0.00378	0.00034	0.00032	0.00004	0.00015	4.35553	0.00057	0.00001	4.37123
		Combination Short-haul Truck	0.00039	0.00627	0.00197	0.00020	0.00019	0.00003	0.00005	4.03462	0.00015	0.00001	4.03948
		Single Unit Long-haul Truck	0.00041	0.00350	0.00187	0.00012	0.00011	0.00002	0.00006	2.56280	0.00021	0.00001	2.56867
		Single Unit Short-haul Truck	0.00087	0.00602	0.00329	0.00025	0.00023	0.00002	0.00010	2.84028	0.00030	0.00001	2.84685
		Refuse Truck	0.00075	0.01157	0.00379	0.00051	0.00047	0.00004	0.00008	4.38876	0.00018	0.00001	4.39449
		Light Commercial Truck	0.00154	0.00428	0.01240	0.00016	0.00015	0.00001	0.00017	1.60958	0.00039	0.00001	1.61536
		Passenger Truck	0.00059	0.00184	0.00398	0.00005	0.00005	0.00001	0.00009	1.38976	0.00032	0.00001	1.39405
		Passenger Car	0.00054	0.00038	0.00509	0.00001	0.00001	0.00001	0.00008	0.64176	0.00034	0.00000	0.64414
	Gasoline	Combination Short-haul Truck	0.00739	0.01249	0.23011	0.00053	0.00047	0.00006	0.00077	4.00483	0.00035	0.00017	4.05264
		Single Unit Long-haul Truck	0.00151	0.00318	0.04959	0.00007	0.00006	0.00004	0.00016	2.51162	0.00005	0.00005	2.52408
		Single Unit Short-haul Truck	0.00148	0.00296	0.05316	0.00006	0.00005	0.00004	0.00015	2.66765	0.00007	0.00007	2.68509
		Refuse Truck	0.00225	0.00456	0.03411	0.00010	0.00009	0.00006	0.00024	4.30993	0.00004	0.00006	4.32644
		Light Commercial Truck	0.00107	0.00110	0.01571	0.00004	0.00003	0.00002	0.00010	1.05180	0.00005	0.00004	1.06565
		Passenger Truck	0.00064	0.00064	0.00983	0.00003	0.00002	0.00001	0.00006	0.93536	0.00003	0.00003	0.94460
		Passenger Car	0.00091	0.00063	0.01004	0.00003	0.00003	0.00001	0.00009	0.74467	0.00003	0.00002	0.75269

Note: Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014 model and inputs for calendar year 2022 using the latest input files for calendar year 2020 from the New York State Department of Environmental Conservation.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2)
Table K-1-33. EPA NEI HAP Emission Factors for Commercial Marine Vessels

HAP emission factors for commercial marine vessels were determined using the methodology identified by US EPA for the 2017 National Emissions Inventory (NEI); i.e., they are calculated as percentages of the PM2.5 or VOC emissions from the CMVs.

Pollutant	HAP?*	Fraction of	Fraction (All engines Cat 1/2/3, all fuel types, all operating modes)
Ammonia	No	PM2.5	0.019247
Antimony	Yes	PM2.5	0.000615
Arsenic	Yes	PM2.5	2.59E-05
Benz[a]Anthracene	Yes	PM2.5	8.82E-06
Benzo(g,h,i)Perylene	Yes	PM2.5	0.000132
Benzo[a]Pyrene	Yes	PM2.5	4.18E-06
Benzo[b]Fluoranthene	Yes	PM2.5	8.35E-06
Benzo[k]Fluoranthene	Yes	PM2.5	4.18E-06
Cadmium	Yes	PM2.5	0.000236
Chromium (VI)	Yes	PM2.5	7.24E-09
Chrysene	Yes	PM2.5	1.63E-05
Dibenzo[a,h]anthracene	Yes	PM2.5	8.65E-06
Fluoranthene	Yes	PM2.5	8.97E-05
Indeno[1,2,3-c,d]Pyrene	Yes	PM2.5	8.35E-06
Lead	Yes	PM2.5	0.000125
Manganese	Yes	PM2.5	3.22E-06
Mercury	Yes	PM2.5	4.18E-08
Nickel	Yes	PM2.5	0.000687
Polychlorinated Biphenyls	Yes	PM2.5	4.18E-07
Pyrene	Yes	PM2.5	3.37E-05
Selenium	Yes	PM2.5	4.38E-08
Total HAP (ratioed to PM2.5)			**0.0213**
1,3-Butadiene	Yes	VOC	0.001013
2,2,4-Trimethylpentane	Yes	VOC	0.00712
Acenaphthene	Yes	VOC	5.09E-05
Acenaphthylene	Yes	VOC	0.000118
Acetaldehyde	Yes	VOC	0.009783
Acrolein	Yes	VOC	0.001848
Anthracene	Yes	VOC	0.000344
Benzene	Yes	VOC	0.004739
Ethyl Benzene	Yes	VOC	0.000439
Fluorene	Yes	VOC	0.000164
Formaldehyde	Yes	VOC	0.042696
Hexane	Yes	VOC	0.00279
Naphthalene	Yes	VOC	0.00273
o-Xylene	Yes	VOC	0.000513
Phenanthrene	Yes	VOC	0.001356
Propionaldehyde	Yes	VOC	0.001517
Toluene	Yes	VOC	0.002035
Xylenes (Mixed Isomers)	Yes	VOC	0.001422
Total HAP (ratioed to VOC)			**0.0807**

*For completeness, all of the pollutants in EPA's database are shown, but not all are HAP as defined in Section 112 of the Clean Air Act and as updated in 40 CFR 63 Subpart C.

Reference: US EPA, "2017 National Emissions Inventory (NEI)," April 2020, available from https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data.
HAP speciation profiles for Category 1 and 2 engines are from Table 8 of the 2017 NEI "Methodology Documentation for EPA's Commercial Marine Emissions Estimates" for Category 1 and 2 vessels. HAP speciation profiles for Category 3 engines are from Table 15 of the "Methodology Documentation for EPA's Commercial Marine Emissions Estimates" for Category 3 vessels. Both documents are available from https://www.epa.gov/sites/production/files/2019-11/cmv_methodology_documentation.zip.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2)

Table K-1-34. HAP Emission Factor Calculation Sheet

Small Diesel Engines

Pollutant		Emission Factor (lb/MMBtu)[a]	Emission Factor Rating	Source (AP-42 Table)
Organic Compounds				
Benzene[b]		9.33E-04	E	3.3-2
Toluene[b]		4.09E-04	E	3.3-2
Xylene[b]		2.85E-04	E	3.3-2
1,3 Butadiene	<	3.91E-05	E	3.3-2
Propylene		2.58E-03	E	3.3-2
Formaldehyde[b]		1.18E-03	E	3.3-2
Acetaldehyde[b]		7.67E-04	E	3.3-2
Acrolein[b]	<	9.25E-05	E	3.3-2
PAH				
Naphthalene[b]		8.48E-05	E	3.3-2
Acenaphthylene[b]	<	5.06E-05	E	3.3-2
Acenaphthene[b]	<	1.42E-06	E	3.3-2
Fluorene[b]		2.92E-05	E	3.3-2
Phenanthrene[b]		2.94E-05	E	3.3-2
Anthracene[b]		1.87E-06	E	3.3-2
Fluoranthene[b]		7.61E-06	E	3.3-2
Pyrene[b]		4.78E-06	E	3.3-2
Benzo(a)anthracene[b]		1.68E-06	E	3.3-2
Chrysene[b]		3.53E-07	E	3.3-2
Benzo(b)fluoranthene[b]	<	9.91E-08	E	3.3-2
Benzo(k)fluoranthene[b]	<	1.55E-07	E	3.3-2
Benzo(a)pyrene[b]	<	1.88E-07	E	3.3-2
Indeno(1,2,3-cd)pyrene[b]	<	3.75E-07	E	3.3-2
Dibenz(a,h)anthracene[b]	<	5.83E-07	E	3.3-2
Benzo(g,h,i)perylene[b]	<	4.89E-07	E	3.3-2
TOTAL PAH		1.68E-04	E	3.3-2
Metals and inorganics[c]				
Arsenic[b]		4.62E-08		
Cadmium[b]		5.13E-09		
Chromium[b]		1.24E-05		
Chromium VI[b, d]		2.24E-06		
Lead[b]		7.69E-07		
Mercury[b]		1.03E-08		
Nickel[b]		1.48E-06		
Selenium[b]		2.56E-07		

Total for substances identified as HAP[e]	<	3.89E-03

[a] Values preceded by "<" are based on method detection limits.

[b] Specifically listed as a "Hazardous Air Pollutant" (HAP) in the Clean Air Act, or a component of Polycyclic Organic Matter, which is also listed as a HAP.

[c] Metal emissions are based on the paper *Survey of Ultra-Trace Metals in Gas Turbine Fuels,* 11th Annual International Petroleum Conference, Oct 12-15, 2004. Where trace metals were detected in any of 13 samples, the average result is used. Where no metals were detected in any of 13 samples, the detection limit is used.

[d] Hexavalent chrome was not detected in any fuel oil samples (in the note c reference study). However, to allow for potential hex chrome emissions formed during combustion, 18% of the total chrome emissions were assumed to be hex chrome (per EPA 453/R-98-004a)

[e] Total calculated using the TOTAL PAH emission factor instead of factors for individual PAH.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2)

Table K-1-35. HAP Emission Factor Calculation Sheet

Large Stationary Diesel Engines

Pollutant		Emission Factor (lb/MMBtu)[a]	Emission Factor Rating	Source (AP-42 Table)
Organic Compounds				
Benzene[b]		7.76E-04	E	3.4-3
Toluene[b]		2.81E-04	E	3.4-3
Xylene[b]		1.93E-04	E	3.4-3
Propylene		2.79E-03	E	3.4-3
Formaldehyde[b]		7.89E-05	E	3.4-3
Acetaldehyde[b]		2.52E-05	E	3.4-3
Acrolein[b]		7.88E-06	E	3.4-3
PAH				
Naphthalene[b]		1.30E-04	E	3.4-4
Acenaphthylene[b]		9.23E-06	E	3.4-4
Acenaphthene[b]		4.68E-06	E	3.4-4
Fluorene[b]		1.28E-05	E	3.4-4
Phenanthrene[b]		4.08E-05	E	3.4-4
Anthracene[b]		1.23E-06	E	3.4-4
Fluoranthene[b]		4.03E-06	E	3.4-4
Pyrene[b]		3.71E-06	E	3.4-4
Benz(a)anthracene[b]		6.22E-07	E	3.4-4
Chrysene[b]		1.53E-06	E	3.4-4
Benzo(b)fluoranthene[b]		1.11E-06	E	3.4-4
Benzo(k)fluoranthene[b]	<	2.18E-07	E	3.4-4
Benzo(a)pyrene[b]	<	2.57E-07	E	3.4-4
Indeno(1,2,3-cd)pyrene[b]	<	4.14E-07	E	3.4-4
Dibenz(a,h)anthracene[b]	<	3.46E-07	E	3.4-4
Benzo(g,h,i)perylene[b]	<	5.56E-07	E	3.4-4
TOTAL PAH	<	2.12E-04	E	3.4-4
Metals and inorganics[c]				
Arsenic[b]		4.62E-08		
Cadmium[b]		5.13E-09		
Chromium[b]		1.24E-05		
Chromium VI[b, d]		2.24E-06		
Lead[b]		7.69E-07		
Mercury[b]		1.03E-08		
Nickel[b]		1.48E-06		
Selenium[b]		2.56E-07		

Total for substances identified as HAP[e]	<	1.59E-03

[a] Values preceded by "<" are based on method detection limits.

[b] Specifically listed as a "Hazardous Air Pollutant" (HAP) in the Clean Air Act, or a component of Polycyclic Organic Matter, which is also listed as a HAP.

[c] Metal emissions are based on the paper *Survey of Ultra-Trace Metals in Gas Turbine Fuels,* 11th Annual International Petroleum Conference, Oct 12-15, 2004. Where trace metals were detected in any of 13 samples, the average result is used. Where no metals were detected in any of 13 samples, the detection limit is used.

[d] Hexavalent chrome was not detected in any fuel oil samples (in the note f reference study). However, to allow for potential hex chrome emissions formed during combustion, 18% of the total chrome emissions were assumed to be hex chrome (per EPA 453/R-98-004a)

[e] Total calculated using the TOTAL PAH emission factor instead of factors for individual PAH.

EMPIRE OFFSHORE WIND: EMPIRE WIND PROJECT (EW 1 and EW 2)

Table K-1-36. EPA NEI HAP Emission Factors for Nonroad Diesels

HAP emission factors for nonroad diesels (below) were obtained from ERG, "Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Nonroad Components of the National Emissions Inventory," Volume I - Methodology, October 7, 2003 (available from http://www.epa.gov/ttn/chief/net/1999inventory.html#final3haps), Appendix D, Tables D-1 through D-3. This is the reference cited by EPA's National Inventory Model (NMIM), i.e., US EPA, "EPA's National Inventory Model (NMIM), A Consolidated Emissions Modeling System for MOBILE6 and NONROAD", EPA420-R-05-024, December 2005 (available from http://www.epa.gov/otaq/models/nmim/420r05024.pdf), pp. 19-21.

Pollutant	Fraction of	Emissions Factor %
1,3-butadiene	VOC - Exhaust	0.0018616
formaldehyde	VOC	0.11815
benzene	VOC	0.020344
acetaldehyde	VOC	0.05308
ethylbenzene	VOC - Exhaust	0.0031001
styrene	VOC - Exhaust	0.00059448
acrolein	VOC	0.00303
toluene	VOC	0.014967
hexane	VOC	0.0015913
propionaldehyde	VOC	0.011815
2,2,4-trimethylpentane	VOC	0.000719235
2,3,7,8-TCDD TEQ **	tons TEQ/gal	1.90705E-14
xylenes	VOC	0.010582
Total HAP (ratioed to VOC)		**0.239834715**
PAH		
benz[a]anthracene	PM10	0.0000071
benzo[a]pyrene	PM10	0.00000035
benzo[b]fluoranthene	PM10	0.00000049
benzo[k]fluoranthene	PM10	0.00000035
chrysene	PM10	0.0000019
dibenzo[a,h]anthracene	PM10	2.9E-09
indeno[1,2,3-c,d]pyrene	PM10	0.000000079
acenaphthene	PM10	0.0001
acenaphthylene	PM10	0.000084
anthracene	PM10	0.00000043
benzo[g,h,i]perylene	PM10	0.00000019
fluoranthene	PM10	0.000017
fluorene	PM10	0.0001
naphthalene	PM10	0.00046
phenanthrene	PM10	0.00026
pyrene	PM10	0.0000029
Total HAP (ratioed to PM10)		**0.001034792**
chromium	ug/bhp-hr	0.03
manganese	ug/bhp-hr	1.37
nickel	ug/bhp-hr	2.035
Total HAP (Metals ug/bhp-hr)		**3.435**

** Note: the emission rate for 2,3,7,8-TCDD TEQ is significantly lower than any other HAP and therefore, was not factored into the total HAP emission factor.