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Appendix N: Air Emissions Calculations and Methodology

Coastal Virginia Offshore Wind Commercial Project

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CONSTRUCTION AND OPERATIONS PLAN
Coastal Virginia Offshore Wind Commercial Project

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ACRONYMS AND ABBREVIATIONS

Btu	British thermal unit
CFR	Code of Federal Regulations
CH_4	methane
CMV	commercial marine vessel
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EPA	United States Environmental Protection Agency
gal	gallon
g/lb	grams per pound
GHG	greenhouse gas
GWP	global warming potential
HAP	hazardous air pollutant
hp	horsepower
ICF	ICF International
kg	kilogram
km	kilometer
kW	kilowatt
lb	pound
Lease Area	Bureau of Ocean Energy Management-designated Renewable Energy Lease Area OCS-A-0483
NEPA	National Environmental Policy Act
nm	nautical mile
NO_X	nitrogen oxides
N_2O	nitrous oxide
O&M	operations and maintenance
OCS	Outer Continental Shelf
OGV	ocean-going vessels
PM	particulate matter
PM_{10}	particulate matter with aerodynamic diameter 10 micrometers or less
$PM_{2.5}$	particulate matter with aerodynamic diameter 2.5 micrometers or less
Project	Coastal Virginia Offshore Wind Commercial Project
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
VOC	volatile organic compounds
WTG	wind turbine generator

N.1 INTRODUCTION

The Virginia Electric and Power Company, doing business as Dominion Energy Virginia (Dominion Energy), is proposing to construct, own, and operate the Coastal Virginia Offshore Wind Commercial Project (Project). The Project will be located in the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf (OCS) Offshore Virginia (Lease No. OCS-A-0483) (Lease Area), which was awarded through the Bureau of Ocean Energy Management competitive renewable energy lease auction of the Wind Energy Area offshore of Virginia in 2013. The Lease Area covers approximately 112,799 acres (ac, 45,658 hectares [ha]) and is approximately 27 statute miles (mi, 23.75 nautical miles [nm], 43.99 kilometers [km]) off the Virginia Beach coastline (Figure N-1).

The purpose of this Project is to provide between 2,500 and 3,000 megawatts of clean, reliable offshore wind energy; to increase the amount and availability of renewable energy to Virginia consumers; to create the opportunity to displace electricity generated by fossil fuel-powered plants; and to offer substantial economic and environmental benefits to the Commonwealth of Virginia. This Project represents a viable and needed opportunity for Virginia to obtain clean renewable energy and realize its economic and environmental goals.

This appendix describes the methodology applied to calculate the air emissions associated with the Project, as well as the results of the emissions calculations, which are detailed in Attachment N-1. There are six categories of sources for which emissions were calculated:

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

The specific air pollutants estimated from the above-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 Pollutants:
  - Nitrogen oxides (NO_X);
  - Volatile organic compounds (VOCs);
  - 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 ($PM_{2.5}$); and
  - Sulfur dioxide (SO_2).

- HAPs, which include but are not limited to:
  - Formaldehyde;
  - Acetaldehyde;
  - Benzene;
  - Naphthalene;
  - Acrolein;
  - 1,3-Butadiene;
  - Ethylbenzene; and
  - Polycyclic Organic Matter.
- GHGs:
  - Carbon dioxide (CO_2);
  - Methane (CH_4);
  - Nitrous oxide (N_2O); and
  - Sulfur hexafluoride (SF_6).

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

N.2 EMISSION CALCULATION METHODS

Methods for calculating criteria pollutant emissions for the respective emission source categories are summarized in Sections N.2.1 through N.2.5. Section N.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" (CO_2e) because the different GHG constituents have different heat absorption capacities.

N.2.1 Commercial Marine Vessels

The calculations presented in Attachment N-1 are based on an assumed typical vessel representative of the type, configuration, and size that the Project anticipates will be employed during Project construction and operations and maintenance (O&M). Any vessel name included is presented for illustrative purposes only, each representing a reasonable worst-case scenario with respect to the potential emissions of the identified vessel category. Actual vessels to be employed during construction and O&M activities are subject to change. Vessel operating durations are based on anticipated schedules provided by the Project and may also be subject to change; the durations and schedules have been selected to represent a reasonable worst-case scenario with respect to potential emissions.

N.2.1.1 Emission Factors

The U.S. Environmental Protection Agency (EPA) contracted with ICF International (ICF) to produce a guidance document for estimating CMV emissions: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories (ICF 2009), which categorizes most vessels, including tugboats and crew

boats, as "harbor craft," and which categorizes ships with larger engines as "ocean-going vessels" (OGVs). The ICF factors selected for estimating emissions from harbor craft and OGVs are presented in Table N-1.

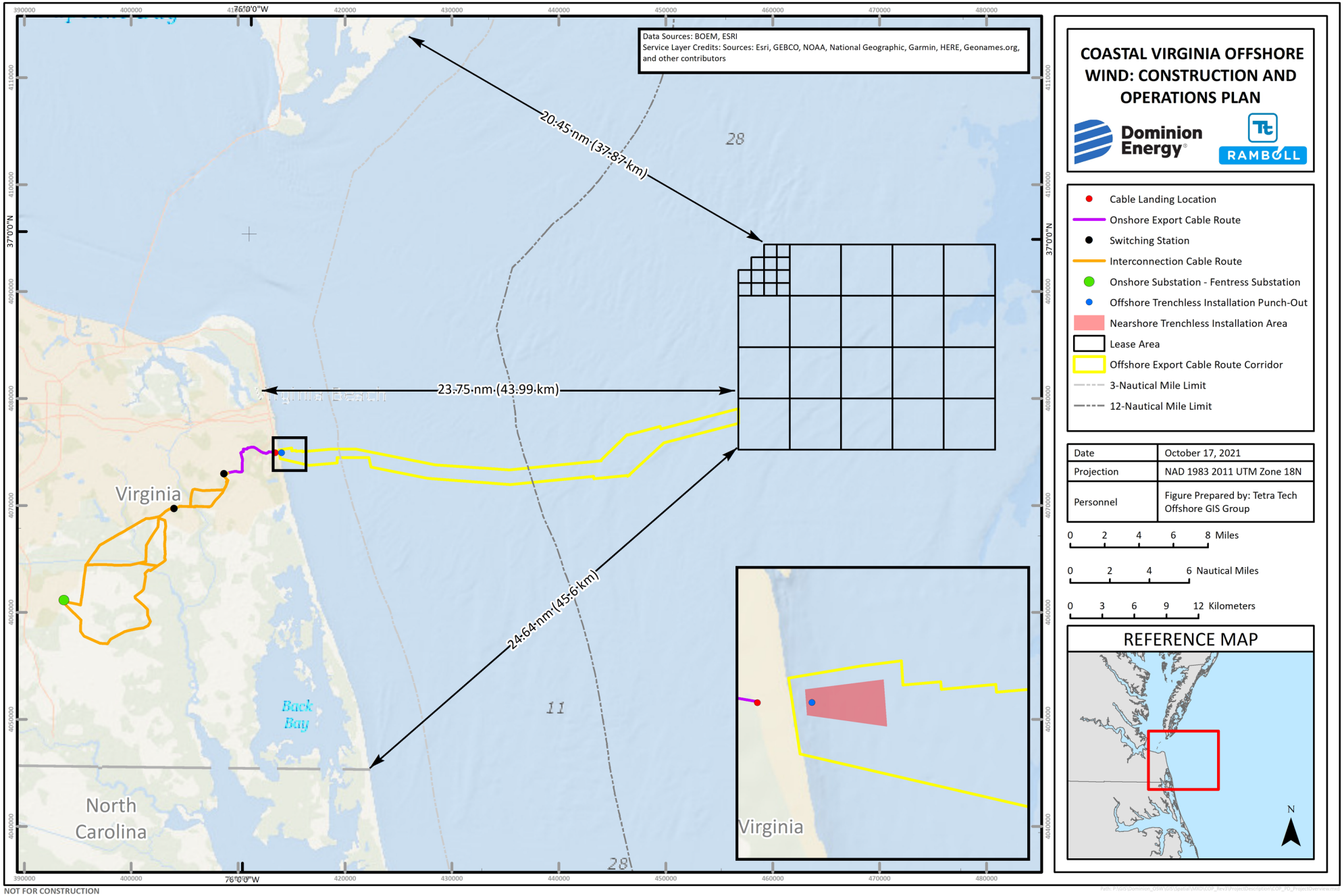

Figure N-1. Project Area Overview

Table N-1. Summary of Harbor Craft and Ocean-Going Vessels Emission Factors

Minimum Power (kilowatts [kW])		Emission Factor (gram/kW-hour)							
		NO_X	VOC	CO	PM_{10}/ $PM_{2.5}$	SO_2	CO_2	CH_4	N_2O
Harbor Craft – Worst-Case Rate for Tier 1 and Tier 2 Engines									
Category 1	37 – 75 kW	9.8	0.27	5	0.77	0.0065	690	0.09	0.02
	75 – 130 kW	9.8	0.27	5	0.34	0.0065	690	0.09	0.02
	130 – 225 kW	9.8	0.27	5	0.34	0.0065	690	0.09	0.02
	225 – 450 kW	9.8	0.27	5	0.26	0.0065	690	0.09	0.02
	450 – 560 kW	9.8	0.27	5	0.26	0.0065	690	0.09	0.02
	560 – 1000 kW	9.8	0.27	5	0.26	0.0065	690	0.09	0.02
	1,000+ kW	9.8	0.27	5	0.26	0.0065	690	0.09	0.02
Category 2	All sizes	9.8	0.5	5	0.62	0.0065	690	0.09	0.02
Ocean-going Vessels									
Category 3	Main Engines	13.2	0.50	1.10	0.19	0.397	646.08	0.004	0.031
	Auxiliary Engines	13.9	0.40	1.10	0.18	0.424	690.71	0.004	0.031

Notes:

1. Category 1 engines are main or auxiliary engines rated at less than 1,000 kW, Category 2 engines are those rated at 1,000 kW or greater with a displacement less than 30 liters per cylinder, and Category 3 engines are those with a displacement equal to or greater than 30 liters per cylinder.
2. The PM_{10} emission factors presented above for Category 1 and 2 engines have had an adjustment factor applied, as recommended in Section 3.4.2 of the ICF report (ICF 2009) since the factors as presented in Table 3-8 of the ICF report are based on a fuel sulfur content of 1.5 percent. These factors were adjusted for the now-required 15 parts per million by weight sulfur content in ultra-low sulfur diesel fuel, by multiplying the emission factors by 0.86.
3. The emission factors for the Category 3 engines were based on a medium-speed diesel vessel using marine diesel oil fuel. The PM_{10} emission factors for Category 3 engines are based on the formulas provided in Section 2.6 of the ICF report and assumed use of marine diesel oil fuel with 0.1-percent sulfur content.

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

- Category 1: Main or auxiliary engines rated at less than 1,000 kilowatts (kW);
- Category 2: Main or auxiliary engines rated at 1,000 kW or greater (but with a displacement of less than 30 liters per cylinder); and
- Category 3: Main or auxiliary engines with a displacement equal to or greater than 30 liters per cylinder.

Most of the marine vessels used for Project construction and O&M are assumed to be equipped with either Category 1 or Category 2 engines and will qualify as 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 (0.0015 percent by weight). Some of the larger installation vessels will be equipped with Category 3 main engines, and these vessels have been assumed to use marine diesel oil with a sulfur content of 0.1 percent by weight.

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 vessels:

- Heavy lift vessels;
- Heavy transport vessels;
- Fall pipe vessels;
- Wind turbine generator (WTG) installation vessel;
- WTG supply vessel; and
- Farshore export and Inter-Array Cable lay vessels.

For these Category 3 engines, the analysis used the ICF emission factors for OGVs, as presented in Table 2-9 of the ICF report. The emission factors for OGVs are based on a 2002 analysis of emission data prepared by Entec (2002). For PM_{10}, the OGV emission factors originally presented in Table 2-9 of the ICF report are based on a fuel sulfur content of 1.0 percent. These factors were adjusted to comply with the International Maritime Organization's North America Sulfur Emissions Control Area requirements, which limit fuel sulfur content to 0.1 percent sulfur by weight. For these vessels, factors for PM_{10} were calculated using the formulas provided in Section 2.6 of the ICF report, assuming the use of marine diesel oil, and using the appropriate values for brake specific fuel consumption provided in Table 2-9 (main engines) and Table 2-16 (auxiliary engines).

The harbor craft emission factors for PM_{10} originally presented in Table 3-8 of the ICF report are based on a fuel sulfur content of 1.5 percent. To adjust these emission factors to reflect the now-required use of ultra-low sulfur diesel fuel, the factors were multiplied by an adjustment factor of 0.86, as recommended in Table 3-9 of the ICF report. For other criteria pollutants, the emission factors for harbor vessels are based on EPA marine engine emissions standards (i.e., Tier 0 to Tier 3 based on cylinder displacement) and their respective EPA engine categories for CMV main propulsion engines and auxiliary engines. EPA established a tier structure for the emission standards based on 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; however, for the purpose of estimating the CMV emissions for the Project

during which harbor craft with older engines might be utilized, the analysis used the worst-case Tier 1 or Tier 2 emission factors, providing a conservative estimate. (Harbor craft meeting Tier 3 emission standards may be used if they are available, and if it is practical to do so.)

For all engine categories, SO_2 emission factors are based on a mass balance calculation for the appropriate fuel sulfur content of each fuel: 0.1 percent sulfur for MARPOL-compliant marine fuel, and 0.0015 percent for ultra-low sulfur diesel fuel. The fuel consumption rate for each engine type was converted to a mass of fuel using an assumed fuel density of 853 kilograms per cubic meter (7.11 pounds per gallon [lb/gal]).

Emissions of HAPs for the marine vessel main engines and auxiliary generators were determined using the methodology EPA identified for the 2017 National Emissions Inventory, which provides emission factors for each HAP compound as a percentage of the $PM_{2.5}$ or VOC emissions from CMVs. These are tabulated in Attachment N-1.

N.2.1.2 Load Factors

For all marine vessel construction and O&M 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.

N.2.1.3 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, grams per kilowatt-hour.

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

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

N.2.2 Stationary Engines

N.2.2.1 Offshore Substation and Onshore Generator Engines

Each of the three Offshore Substation platforms is assumed to be equipped with one diesel generator engine rated at 500 kW mechanical output. The Switching Station is assumed to be equipped with three spark-ignition generator engines rated at 260 kW each (total of 780 kW) mechanical output and firing either natural gas or propane. The Onshore Substation is assumed to be equipped with three spark-ignition

generator engines, rated at 410 kW, 310 kW, and 150 kW mechanical output respectively, and firing either natural gas or propane. The onshore O&M Base is assumed to be equipped with one compression-ignition generator engine rated at 250 kW mechanical output and firing ultra-low sulfur diesel fuel. The Offshore Substation generator engines are assumed to be used for both emergency and non-emergency generation. The onshore generator engines are assumed to be used only for emergency generation, as well as for readiness testing and maintenance purposes. For both the Offshore Substation and onshore engines, potential emissions were estimated by conservatively assuming up to 500 operating hours per year for each engine.

Emissions of NO_X, CO, VOC, and PM from the Offshore Substation engines were assumed to meet the corresponding EPA Tier 4 final emission standards in Table 1 of Title 40 of the Code of Federal Regulations (CFR) § 1039.101 for non-emergency engines of the appropriate size category. Emissions of SO_2 from the Offshore Substation engines 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 Offshore Substation engines were based on factors presented in EPA's AP-42 Compilation of Air Pollutant Emission Factors, Sections 3.3 and 3.4, for small and large diesel engines, respectively (EPA 1995).

Emissions of NO_X, CO, and VOC from the onshore generator engines were assumed to meet the Tier 2 standards in 40 CFR § 1048.101, paragraph (a)(2). Emission of PM_{10}, $PM_{2.5}$, SO_2, and HAP from the onshore generator engines are from AP-42, Table 3.2-3, for four-stroke rich-burn natural gas-fired engines.

Emissions of GHG pollutants (CO_2, CH_4, and N_2O) from both the Offshore Substation engines and the onshore generator engines were based on the appropriate 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 (lb/million British thermal unit [Btu]) were multiplied by the hourly heat input rate (million Btu/hr, calculated based on an assumed heat rate of 7,000 Btu per horsepower hour [hp-hr]) and by the total annual operating hours, converting from pounds to ton (2,000 lb/ton).

N.2.3 Nonroad Engines

Emission factors for mobile source, nonroad engines to be used during the construction of the Cable Landing Location, Onshore Export Cable, Switching Station, Onshore Substation, and Interconnection Cable, as well as for onshore pre-assembly, onshore T&I, and onshore operations and maintenance activities (including cranes, forklifts, excavators, front-end loaders, generators, horizontal directional 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 an assumed construction start year of 2024, using the national database and inventory mode.

Emission factors from the EPA's MOVES2014b emission model are provided for VOC, NO_X, CO, PM_{10}, $PM_{2.5}$, SO_2, CO_2, and CH_4 in units of grams per horsepower-hour, so emissions were estimated by

multiplying the emission factor by the nonroad 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 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). Emission of HAPs are based on factors from ERG (2003, as cited in EPA 2005), Appendix D, Tables D-1–D-3. Emissions for N_2O are based on EPA emission factors for construction equipment in Table B-8 of Direct Emissions from Mobile Combustion Sources (EPA 2016) (that is, 0.26 g N_2O/gal fuel). Fuel consumption for each type of equipment was estimated based on CO_2 emission factor (grams per horsepower-hour) generated from the MOVES2014b model and the emission factor for the mass of CO_2 generated per gallon of diesel fuel (10.21 kilograms [kg] CO_2 per gal fuel), as presented in Table A-1 of EPA (2016).

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

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

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 N.2.6.

N.2.4 On-Road Vehicles

MOVES2014b was used to estimate emissions associated with on-road engines used during construction of the Cable Landing Location, Onshore Export Cable, Switching Station, Onshore Substation, and Interconnection Cable, for an assumed construction start year of 2024. 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 2024 using the most current database files input into MOVES2014b. Input values were provided by the Virginia Department of Environmental Quality for Virginia Beach and Chesapeake. For each pollutant, the worst-case output value between Virginia Beach and Chesapeake was used to estimate on-road vehicle emissions for the Project.

N.2.5 Helicopters

One helicopter is currently assumed to be used to perform crew transfers during construction, as well as during O&M. 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 Virginia Beach Airport as the assumed departure location. Emissions were based on four round trips per week during construction in calendar years 2024 through 2026, and up to 50 round trips per year during O&M, with a round trip duration of 45 minutes per flight.

N.2.6 Gas-Insulated Switchgear

The Offshore Substation platforms, Switching Station, and Onshore Substation 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. Emissions of SF_6 from the switchgear at the Offshore Substations, the Switching Station, and the Onshore Substation 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 (Blackman et al. 2017).

N.2.7 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 (CO_2, CH_4, N_2O, and SF_6) are typically presented in CO_2e, based on the specific global warming potential (GWP) for each gas.

Each GHG constituent has a different heat trapping capability. EPA has calculated the corresponding GWP 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 1 for CO_2, 25 for CH_4, 298 for N_2O, and 22,800 for SF_6. Therefore, the equation to calculate CO_2e for each of the sources is:

$$CO_2e = \left[CO_2 \frac{\text{tons}}{\text{yr}} \times CO_2\ \text{GWP}(1)\right] + \left[CH_4 \frac{\text{tons}}{\text{yr}} \times CH_4\ \text{GWP}(25)\right] + \left[N_2O \frac{\text{tons}}{\text{yr}} \times N_2O\ \text{GWP}(298)\right] + \left[SF_6 \frac{\text{tons}}{\text{yr}} \times SF_6\ \text{GWP}(22{,}800)\right]$$

N.3 GEOGRAPHIC ALLOCATION OF EMISSIONS

Some of the CMVs will make a number of round trips to and from shore during Project construction and O&M. 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 OCS source and an onshore port location. 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 (46.3 km) of the OCS source will be assigned to the OCS source potential emissions inventory when an OCS source is present. Transit emissions occurring in state waters will be assigned to the Air Quality Control Region in which they occur, for the purpose of addressing National Environmental Policy Act (NEPA) requirements and/or General Conformity requirements, if applicable. The Hampton Roads Air Quality Control Region is a maintenance area for the 1997 8-hour ozone standard, and Dominion Energy has been informed by EPA and VDEQ that General Conformity requirements apply. Those areas that are within 25 nm (46.3 km) of the Lease Area but also within state waters will only be considered for General Conformity and/or NEPA requirements. Those portions of the transit emissions that occur in waters located beyond 3 nm (5.6 km) from shore and also beyond 25 nm (46.3 km) from the OCS source have not been included in either potential emissions inventory (with the exception of the transits from the Gulf of Mexico for the Offshore Substation jacket foundations and topsides).

The Project may use a local port located in Chesapeake, Hampton, Newport News, Norfork, or Portmouth, Virginia. For the purpose of estimating emissions, it has been assumed that Portsmouth, Virginia, will be the local port and staging area for all purposes during Project construction, and that Lambert's Point in Norfolk, Virginia will be the local port and staging area for all purposes during Project O&M, with the following exception:

- A yet-to-be-determined port in the Gulf of Mexico is assumed to be the starting point for transporting the jacket foundation and topside for each Offshore Substation platform. Ingleside, Texas, has been assumed for the purpose of estimating transit distances.

N.3.1 Vessel Transits to Shore

To determine the maximum potential transit emissions for OCS air permitting and NEPA purposes, the following one-way transit distances from either Portsmouth or Lambert's Point, Virginia, to the Lease Area were used to allocate vessel transit emissions by geographic area:

- Portsmouth or Lambert's Point, Virginia to the center of the Lease Area (each way):
    - Virginia state waters within the Hampton Roads Air Quality Control Region: 30.0 nm (55.6 km)
    - Federal waters outside the OCS radius: 0 nm (0 km)
    - Inside OCS radius: 30.0 nm (55.6 km)
    - TOTAL: 60.0 nm (111.1 km)

An average transit speed of 10 knots (18.5 km/hour) was assumed for all vessels. Emissions for all transits located within the 25-nm (46.3-km) OCS source perimeter are inventoried for the OCS air permit.

Emissions for all transits located within state waters are inventoried for NEPA purposes.

Emissions for those portions of transits that are outside the 25 nm (46.3 km) OCS source perimeter (and are also outside state waters) have not been inventoried, with the exception of the transits from the Gulf of Mexico for the Offshore Substation jacket foundations and topsides. Generally, this results in exclusion of most of the ocean-crossing transit distance from overseas ports to Portsmouth or Lambert's Point, Virginia, or from overseas ports directly to the Lease Area.

N.3.2 Nearshore Export Cable Construction

Emissions from construction of the nearshore portion of the Offshore Export Cable will occur along the Offshore Export Cable Route. For all vessels used in construction of the nearshore portion of the Offshore Export Cable, it has been assumed that all emissions will occur in Virginia state waters (within 3 nm [5.6 km] from shore) located inside the boundaries of Virginia Beach, Virginia.

N.3.3 Farshore Export Cable Construction

Emissions from construction of the farshore portion of the Offshore Export Cable will occur along the Offshore Export Cable Route from the Lease Area to the Cable Landing Location. For all vessels used in construction of the farshore portion of the Offshore Export Cable, it has been assumed that all emissions will occur in federal waters located within the 25 nm (46.3 km) of the OCS source perimeter.

N.3.4 All Other Vessel Activities

With the exception of transits to and from Portsmouth or Lambert's Point, Virginia, and transits from overseas ports, emissions from all other vessel activities during Project construction and O&M were assumed to occur within 25 nm (46.3 km) of the OCS source and are, therefore, part of the OCS source potential to emit.

N.3.5 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 Virginia Beach Airport. 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:

- Virginia Beach Airport to the center of the Lease Area (each way):
    - Overland travel within Virginia Beach: 6.0 statute miles (9.7 km)
    - Virginia state waters within the Hampton Roads Air Quality Control Region: 3.0 statute miles (4.8 km)
    - Inside OCS radius: 32 statute miles (51.5 km)
    - TOTAL: 41 statute miles (66.0 km)

N.4 ONSHORE CONSTRUCTION, OPERATIONS AND MAINTENANCE

Emissions from construction and O&M of the Cable Landing Location, Onshore Export Cable, Switching Station, and the majority of the Interconnection Cable will occur inside the boundaries of Virginia Beach, Virginia. Emissions from construction and O&M of the Onshore Substation and the remaining portion of the Interconnection Cable will occur inside the boundaries of Chesapeake, Virginia. Emissions from operation of the onshore O&M Base will occur inside the boundaries of Norfolk, Virginia.

N.5 SUMMARY OF EMISSIONS BY GEOGRAPHIC AREA

Table N-2 through Table N-6 present the potential emissions for each year of construction. Table N-7 presents the potential emissions during Project O&M.

Table N-2. Construction Emissions for Calendar Year 2023 (tons)

Geographic Area	VOC	NOx	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
Onshore (Virginia Beach, VA)	1.50	21.93	5.90	1.10	1.06	0.07	0.36	9,577.8
Onshore (Chesapeake, VA)	0.25	5.56	0.93	0.19	0.18	0.01	0.06	1,764.1
Onshore Project Area (Norfolk)	0	0	0	0	0	0	0	0
Onshore Project Area (Portsmouth)	0.09	3.16	0.32	0.07	0.06	4.57E-03	0.02	656.9
Texas state waters (Corpus Christi-Victoria Air Quality Control Region)	0	0	0	0	0	0	0	0
Virginia state waters (Hampton Roads Air Quality Control Region)	6.37	165.13	65.18	5.94	5.76	1.42	0.64	10,799.8
Federal waters outside the Outer Continental Shelf radius	0	0	0	0	0	0	0	0
Inside Outer Continental Shelf radius	23.40	598.89	189.39	18.85	18.28	8.40	2.28	36,792.3
TOTAL, ALL AREAS	**31.61**	**794.67**	**261.71**	**26.13**	**25.35**	**9.91**	**3.35**	**59,590.8**

Table N-3. Construction Emissions for Calendar Year 2024 (tons)

Geographic Area	VOC	NOx	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
Onshore (Virginia Beach, VA)	3.03	44.26	11.80	2.20	2.14	0.16	0.71	19,232.3
Onshore (Chesapeake, VA)	0.50	11.12	1.85	0.37	0.36	0.02	0.12	3,528.1
Onshore Project Area (Norfolk)	0	0	0	0	0	0	0	0
Onshore Project Area (Portsmouth)	0.36	12.65	1.29	0.26	0.25	0.02	0.09	2,627.5
Texas state waters (Corpus Christi-Victoria Air Quality Control Region)	0.03	0.67	0.06	9.40E-03	9.12E-03	0.02	2.24E-03	33.2
Virginia state waters (Hampton Roads Air Quality Control Region)	26.17	632.36	291.33	28.28	27.44	2.58	2.69	43,498.6
Federal waters outside the Outer Continental Shelf radius	1.45	38.16	3.18	0.54	0.52	1.15	0.13	1,894.6
Inside Outer Continental Shelf radius	141.36	3,468.24	938.19	107.62	104.39	59.61	13.61	205,356.3
TOTAL, ALL AREAS	**172.88**	**4,207.46**	**1,247.70**	**139.28**	**135.10**	**63.57**	**17.35**	**276,170.7**

Table N-4. Construction Emissions for Calendar Year 2025 (tons)

Geographic Area	VOC	NOx	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
Onshore (Virginia Beach, VA)	2.28	33.30	8.85	1.65	1.60	0.13	0.53	14,443.4
Onshore (Chesapeake, VA)	0.25	5.56	0.93	0.19	0.18	1.24E-02	0.06	1,764.1
Onshore Project Area (Norfolk)	0	0	0	0	0	0	0	0
Onshore Project Area (Portsmouth)	0.56	16.35	2.44	0.45	0.43	0.03	0.14	4,873.4
Texas state waters (Corpus Christi-Victoria Air Quality Control Region)	0.04	1.00	0.08	0.01	0.01	0.03	3.36E-03	49.9
Virginia state waters (Hampton Roads Air Quality Control Region)	15.36	361.63	157.05	16.15	15.67	2.14	1.57	24,404.8
Federal waters outside the Outer Continental Shelf radius	2.17	57.24	4.77	0.80	0.78	1.72	0.19	2,841.9
Inside Outer Continental Shelf radius	267.56	6,458.92	1,852.07	214.27	207.84	103.74	25.99	387.473.3
TOTAL, ALL AREAS	**288.21**	**6,934.00**	**2,026.19**	**233.53**	**226.52**	**107.81**	**28.49**	**435,850.8**

Table N-5. Construction Emissions for Calendar Year 2026 (tons)

Geographic Area	VOC	NOx	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
Onshore (Virginia Beach, VA)	0.03	0.40	9.36E-03	9.13E-03	9.13E-03	0.02	7.89E-04	76.6
Onshore (Chesapeake, VA)	0	0	0	0	0	0	0	0
Onshore Project Area (Norfolk)	0	0	0	0	0	0	0	0
Onshore Project Area (Portsmouth)	0.36	8.10	1.86	0.31	0.30	0.03	0.09	3,651.4

Geographic Area	VOC	NOx	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
Texas state waters (Corpus Christi-Victoria Air Quality Control Region)	0	0	0	0	0	0	0	0
Virginia state waters (Hampton Roads Air Quality Control Region)	4.77	136.38	60.06	4.53	4.40	0.75	0.48	9,263.7
Federal waters outside the Outer Continental Shelf radius	0	0	0	0	0	0	0	0
Inside Outer Continental Shelf radius	104.36	2,572.13	880.53	91.37	88.63	31.50	10.29	161,722.6
TOTAL, ALL AREAS	**109.52**	**2,717.00**	**942.45**	**96.23**	**93.34**	**32.30**	**10.86**	**174,714.3**

Table N-6. Construction Emissions for Calendar Year 2027 (tons)

Geographic Area	VOC	NOx	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
Onshore (Virginia Beach, VA)	0	0	0	0	0	0	0	0
Onshore (Chesapeake, VA)	0	0	0	0	0	0	0	0
Onshore Project Area (Norfolk)	0	0	0	0	0	0	0	0
Onshore Project Area (Portsmouth)	0.14	2.47	0.77	0.12	0.12	1.05E-02	0.03	1,497.3
Texas state waters (Corpus Christi-Victoria Air Quality Control Region)	0	0	0	0	0	0	0	0
Virginia state waters (Hampton Roads Air Quality Control Region)	2.17	65.47	31.75	2.19	2.12	0.16	0.22	4,580.8
Federal waters outside the Outer Continental Shelf radius	0	0	0	0	0	0	0	0
Inside Outer Continental Shelf radius	41.29	1,071.48	358.71	34.14	33.11	13.66	4.04	66,830.3
TOTAL, ALL AREAS	**43.60**	**1,139.42**	**391.22**	**36.45**	**35.36**	**13.83**	**4.29**	**72,908.4**

Table N-7. Operation and Maintenance Emissions for Calendar Year 2028 Onward (tons)

Geographic Area	VOC	NOx	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	HAP	GHG (CO_2e)
Onshore (Virginia Beach, VA)	0.02	1.24	55.89	0.02	0.02	6.87E-03	0.06	1,755.0
Onshore (Chesapeake, VA)	0.02	1.28	62.33	0.02	0.02	1.20E-03	0.07	2,286.8
Onshore Project Area (Norfolk)	0.02	0.53	17.97	0.02	0.02	1.43E-03	0.02	241.2
Virginia state waters (Hampton Roads Air Quality Control Region)	0.31	8.54	4.34	0.35	0.33	8.56E-03	0.03	614.4
Federal waters outside the Outer Continental Shelf radius	0	0	0	0	0	0	0	0
Inside Outer Continental Shelf radius	17.33	469.59	241.95	19.01	18.44	0.35	1.78	36,616.6
TOTAL, ALL AREAS	**17.71**	**481.18**	**382.48**	**19.42**	**18.83**	**0.37**	**1.96**	**41,214.0**

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ATTACHMENT N-1: EMISSION CALCULATIONS

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Emission Summary

Potential Emissions

Calendar Year 2023

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
Onshore (Virginia Beach, VA)	1.50	21.93	5.90	1.10	1.06	0.07	0.36	9,503.8	0.10	0.24	9,577.8
Onshore (Chesapeake, VA)	0.25	5.56	0.93	0.19	0.18	1.24E-02	0.06	1,750.4	1.38E-02	0.04	1,764.1
Onshore (Norfolk, VA)	0	0	0	0	0	0	0	0	0	0	0
Onshore (Portsmouth, VA)	0.09	3.16	0.32	0.07	0.06	4.57E-03	0.02	651.8	5.41E-03	0.02	656.9
Texas state waters (Corpus Christi-Victoria AQCR)	0	0	0	0	0	0	0	0	0	0	0
Virginia state waters (Hampton Roads AQCR)	6.37	165.13	65.18	5.94	5.76	1.42	0.64	10,667.3	1.12	0.35	10,799.8
Federal waters outside OCS radius	0	0	0	0	0	0	0	0	0	0	0
Inside OCS radius	23.40	598.89	189.39	18.85	18.28	8.40	2.28	36,326.0	3.08	1.31	36,792.3
TOTAL	**31.61**	**794.67**	**261.71**	**26.13**	**25.35**	**9.91**	**3.35**	**58,899.3**	**4.32**	**1.96**	**59,590.8**

Calendar Year 2024

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
Onshore (Virginia Beach, VA)	3.03	44.26	11.80	2.20	2.14	0.16	0.71	19,083.4	0.20	0.48	19,232.3
Onshore (Chesapeake, VA)	0.50	11.12	1.85	0.37	0.36	0.02	0.12	3,500.9	0.03	0.09	3,528.1
Onshore (Norfolk, VA)	0	0	0	0	0	0	0	0	0	0	0
Onshore (Portsmouth, VA)	0.36	12.65	1.29	0.26	0.25	0.02	0.09	2,607.2	0.02	0.07	2,627.5
Texas state waters (Corpus Christi-Victoria AQCR)	0.03	0.67	0.06	9.40E-03	9.12E-03	0.02	2.24E-03	32.8	2.03E-04	1.57E-03	33.2
Virginia state waters (Hampton Roads AQCR)	26.17	632.36	291.33	28.28	27.44	2.58	2.69	42,978.2	5.16	1.31	43,498.6
Federal waters outside OCS radius	1.45	38.16	3.18	0.54	0.52	1.15	0.13	1,867.6	1.16E-02	0.09	1,894.6
Inside OCS radius	141.36	3,468.24	938.19	107.62	104.39	59.61	13.61	202,701.8	14.57	7.69	205,356.3
TOTAL	**172.88**	**4,207.46**	**1,247.70**	**139.28**	**135.10**	**63.57**	**17.35**	**272,771.8**	**19.99**	**9.73**	**276,170.7**

Calendar Year 2025

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
Onshore (Virginia Beach, VA)	2.28	33.30	8.85	1.65	1.60	0.13	0.53	14,331.5	0.15	0.36	14,443.4
Onshore (Chesapeake, VA)	0.25	5.56	0.93	0.19	0.18	1.24E-02	0.06	1,750.4	1.38E-02	0.04	1,764.1
Onshore (Norfolk, VA)	0	0	0	0	0	0	0	0	0	0	0
Onshore (Portsmouth, VA)	0.56	16.35	2.44	0.45	0.43	0.03	0.14	4,835.8	0.04	0.12	4,873.4
Texas state waters (Corpus Christi-Victoria AQCR)	0.04	1.00	0.08	1.41E-02	1.37E-02	0.03	3.36E-03	49.1	3.04E-04	2.36E-03	49.9
Virginia state waters (Hampton Roads AQCR)	15.36	361.63	157.05	16.15	15.67	2.14	1.57	24,110.0	2.75	0.76	24,404.8
Federal waters outside OCS radius	2.17	57.24	4.77	0.80	0.78	1.72	0.19	2,801.4	0.02	0.13	2,841.9
Inside OCS radius	267.56	6,458.92	1,852.07	214.27	207.84	103.74	25.99	382,500.2	29.30	14.23	387,473.3
TOTAL	**288.21**	**6,934.00**	**2,026.19**	**233.53**	**226.52**	**107.81**	**28.49**	**430,378.5**	**32.27**	**15.66**	**435,850.8**

Calendar Year 2026

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
Onshore (Virginia Beach, VA)	0.03	0.40	9.36E-03	9.13E-03	9.13E-03	0.02	7.89E-04	75.80	2.17E-03	2.51E-03	76.60
Onshore (Chesapeake, VA)	0	0	0	0	0	0	0	0	0	0	0
Onshore (Norfolk, VA)	0	0	0	0	0	0	0	0	0	0	0
Onshore (Portsmouth, VA)	0.36	8.10	1.86	0.31	0.30	0.03	0.09	3,623.3	0.02	0.09	3,651.4
Texas state waters (Corpus Christi-Victoria AQCR)	0	0	0	0	0	0	0	0	0	0	0
Virginia state waters (Hampton Roads AQCR)	4.77	136.38	60.06	4.53	4.40	0.75	0.48	9,152.1	1.06	0.29	9,263.7
Federal waters outside OCS radius	0	0	0	0	0	0	0	0	0	0	0
Inside OCS radius	104.36	2,572.13	880.53	91.37	88.63	31.50	10.29	159,696.7	14.65	5.57	161,722.6
TOTAL	**109.52**	**2,717.00**	**942.45**	**96.23**	**93.34**	**32.30**	**10.86**	**172,548.0**	**15.73**	**5.95**	**174,714.3**

Calendar Year 2027

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
Onshore (Virginia Beach, VA)	0	0	0	0	0	0	0	0	0	0	0
Onshore (Chesapeake, VA)	0	0	0	0	0	0	0	0	0	0	0
Onshore (Norfolk, VA)	0	0	0	0	0	0	0	0	0	0	0
Onshore (Portsmouth, VA)	0.14	2.47	0.77	0.12	0.12	1.05E-02	0.03	1,485.8	9.14E-03	0.04	1,497.3
Texas state waters (Corpus Christi-Victoria AQCR)	0	0	0	0	0	0	0	0	0	0	0
Virginia state waters (Hampton Roads AQCR)	2.17	65.47	31.75	2.19	2.12	0.16	0.22	4,526.5	0.57	0.13	4,580.8
Federal waters outside OCS radius	0	0	0	0	0	0	0	0	0	0	0
Inside OCS radius	41.29	1,071.48	358.71	34.14	33.11	13.66	4.04	65,990.1	5.93	2.32	66,830.3
TOTAL	**43.60**	**1,139.42**	**391.22**	**36.45**	**35.36**	**13.83**	**4.29**	**72,002.3**	**6.51**	**2.49**	**72,908.4**

Calendar Year 2028 Onward (O&M)

Emissions by geographic area	VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
Onshore (Virginia Beach, VA)	0.02	1.24	55.89	0.02	0.02	6.87E-03	0.06	271.8	1.26E-02	3.02E-03	1,755.0
Onshore (Chesapeake, VA)	0.02	1.28	62.33	0.02	0.02	1.20E-03	0.07	282.9	1.35E-02	2.70E-03	2,286.8
Onshore (Norfolk, VA)	0.02	0.53	17.97	0.02	0.02	1.43E-03	0.02	239.6	4.88E-03	4.81E-03	241.2
Onshore (Portsmouth, VA)	0	0	0	0	0	0	0	0	0	0	0
Virginia state waters (Hampton Roads AQCR)	0.31	8.54	4.34	0.35	0.33	8.56E-03	0.03	607.2	0.08	0.02	614.4
Federal waters outside OCS radius	0	0	0	0	0	0	0	0	0	0	0
Inside OCS radius	17.33	469.59	241.95	19.01	18.44	0.35	1.78	33,659.1	4.33	0.96	36,316.6
TOTAL	**17.71**	**481.18**	**382.48**	**19.42**	**18.83**	**0.37**	**1.96**	**35,060.6**	**4.44**	**0.99**	**41,214.0**

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Foundation Construction Emissions

																		Total Emissions (Non-Transit)									
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**	**Assumed fuel rate (kg per vessel per day)**	**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 Hours (hrs)**	**Transit Average load (%)**	**Non-Transit Average load (%)**	**Transit Fuel Usage Gallons (per vessel)**	**Non-Transit Fuel Usage Gallons (per vessel)**	**VOC tons**	**NO_x tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Fall Pipe Vessel - Scour protection installation		1	507 x 92 x 44 (26)																									
-Main Generators	2			3	5,147	Diesel	25,000	3.18	163	6	0	1139	24	27,336	38%	38%	320,362	8,954,403	43.99	1,161.21	96.77	16.30	15.81	34.91	3.88	56,836.08	0.35	2.73	57,657.55
-Main Generators	2			2	3,861	Diesel			163	6	0	1139	24	27,336	38%	38%			32.99	646.58	329.89	40.85	39.63	0.43	3.50	45,524.81	5.94	1.32	46,066.49
Crew Transfer Vessel		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	8,000	3.18	292	12	0	583	24	13,992	85%	85%	367,296	1,466,667	6.21	225.39	114.99	5.93	5.76	0.15	0.62	15,868.99	2.07	0.46	16,057.81
-Aux. Generator	1			1	47	Diesel			292	12	0	583	24	13,992	85%	85%			0.12	4.53	2.31	0.12	0.12	3.02E-03	1.25E-02	318.74	0.04	9.24E-03	322.53
-Aux. Engine	1			1	47	Diesel			292	12	0	583	24	13,992	85%	85%			0.12	4.53	2.31	0.12	0.12	3.02E-03	1.25E-02	318.74	0.04	9.24E-03	322.53
Tug 1 for MP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	103	12	0	290	24	6,960	18%	18%	129,560	729,560	5.63	110.30	56.27	6.97	6.76	0.07	0.60	7,765.85	1.01	0.23	7,858.25
-Harbor Generator	1			1	456	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 2 for MP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	103	12	0	290	24	6,960	18%	18%	129,560	729,560	5.63	110.30	56.27	6.97	6.76	0.07	0.60	7,765.85	1.01	0.23	7,858.25
-Harbor Generator	1			1	456	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 3 for MP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	103	12	0	290	24	6,960	18%	18%	129,560	729,560	5.63	110.30	56.27	6.97	6.76	0.07	0.60	7,765.85	1.01	0.23	7,858.25
-Harbor Generator	1			1	456	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 4 for MP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	103	12	0	290	24	6,960	18%	18%	129,560	729,560	5.63	110.30	56.27	6.97	6.76	0.07	0.60	7,765.85	1.01	0.23	7,858.25
-Harbor Generator	1			1	456	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 1 for TP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	52	12	0	290	24	6,960	18%	18%	65,409	729,560	5.63	110.30	56.27	6.97	6.76	0.07	0.60	7,765.85	1.01	0.23	7,858.25
-Harbor Generator	1			1	456	Diesel			52	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			52	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 2 for TP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	52	12	0	290	24	6,960	18%	18%	65,409	729,560	5.63	110.30	56.27	6.97	6.76	0.07	0.60	7,765.85	1.01	0.23	7,858.25
-Harbor Generator	1			1	456	Diesel			52	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			52	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
MP Barges 1 through 4		N/A	400 x 105 x 20 (20)	N/A	N/A	N/A	0	N/A																				
TP Barges 1 through 2		N/A	250 x 70 x 15 (15)	N/A	N/A	N/A	0	N/A																				
Semi-Submersible - MP Transport		N/A	732 x 146 x 43 (33)																									
-Main Generators	2			3	26,300	Diesel	45,000	3.18	19	6	38	0	24	912	24%	24%	67,217	537,736	4.82	127.19	10.60	1.79	1.73	3.82	0.43	6,225.44	0.04	0.30	6,315.42
Deck Carrier - MP/TP Transport		N/A	534 x 138 x 39 (18)																									
-Main Generators	2			2	3,861	Diesel	25,000	3.18	15	6	30	0	24	720	72%	72%	29,481	235,849	1.64	32.15	16.40	2.03	1.97	0.02	0.17	2,263.70	0.30	0.07	2,290.63
-Aux. Generator	1			2	1,332	Diesel			15	6	30	0	24	720	72%	72%			0.28	5.55	2.83	0.35	0.34	3.70E-03	0.03	390.64	0.05	1.13E-02	395.29
-Emergency Generator	1			2	1,332	Diesel			0	6	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 1 for Port Maneuvering		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	0	0	290	0	24	6,960	0%	18%	0	729,560	5.63	110.30	56.27	6.97	6.76	0.07	0.60	7,765.85	1.01	0.23	7,858.25
-Harbor Generator	1			1	456	Diesel			0	0	290	0	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			0	0	290	0	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 2 for Port Maneuvering		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	0	0	290	0	24	6,960	0%	18%	0	729,560	5.63	110.30	56.27	6.97	6.76	0.07	0.60	7,765.85	1.01	0.23	7,858.25
-Harbor Generator	1			1	456	Diesel			0	0	290	0	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			0	0	290	0	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel - MP & TP installation		1	710 x 161 x 55 (36)																									
-Main Engines	4			3	13,814	Diesel	45,000	3.18	1	6	0	387	24	9,288	22%	22%	3,538	5,476,415	46.33	1,222.98	101.92	17.17	16.65	36.76	4.09	59,859.45	0.37	2.87	60,724.61
-Aux. Generators	2			2	1,488	Diesel			1	6	0	387	24	9,288	22%	22%			2.49	48.90	24.95	3.09	3.00	0.03	0.26	3,443.03	0.45	0.10	3,483.99
Noise mitigation vessel 1		N/A	292 x 64 x 24.5 (20)																									
-Main Engines	4			2	2,446	Diesel	10,000	3.18	2	12	0	267	24	6,408	27%	27%	3,145	839,623	6.85	134.21	68.47	8.48	8.23	0.09	0.73	9,449.46	1.23	0.27	9,561.89
Noise mitigation vessel 2		N/A	292 x 64 x 24.5 (20)																									
-Main Engines	4			2	2,446	Diesel	10,000	3.18	2	12	0	267	24	6,408	27%	27%	3,145	839,623	6.85	134.21	68.47	8.48	8.23	0.09	0.73	9,449.46	1.23	0.27	9,561.89
Jack-up Vessel 1 - TP installation		3	434 x 128 x 30																									
-Main Engines	4			3	4,048	Diesel	20,000	3.18	1	6	0	473	24	11,352	35%	35%	1,572	2,974,843	26.65	703.64	58.64	9.88	9.58	21.15	2.35	34,440.16	0.21	1.65	34,937.94
Jack-up Vessel 2 - TP installation		3	434 x 128 x 30																									
-Main Engines	4			3	4,048	Diesel	20,000	3.18	1	6	0	473	24	11,352	35%	35%	1,572	2,974,843	26.65	703.64	58.64	9.88	9.58	21.15	2.35	34,440.16	0.21	1.65	34,937.94
Secondary works vessel		N/A	292 x 64 x 24.5 (20)																									
-Main Engines	4			2	2,446	Diesel	15,000	3.18	66	12	0	463	24	11,112	40%	40%	155,660	2,183,962	17.81	349.10	178.11	22.06	21.40	0.23	1.89	24,579.20	3.21	0.71	24,871.66
																TOTALS	**1,602,044**	**32,320,440**	**268.83**	**6,386.19**	**1,585.50**	**202.28**	**196.21**	**119.44**	**25.86**	**365,535**	**23.85**	**14.24**	**370,374**

Notes:
1. Foundation installation is assumed to occur from October 2023 through November 2025.
2. Non-transit construction emissions 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 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of OCS lease area: 60 nm (VA state waters: 30 nm; OCS radius: 30 nm)
   Overseas port to center of OCS lease area: 30 nm (only includes portion of transit within 25 nm of the OCS lease area)
4. The number of transits for each vessel are based on the following assumptions:
   Weekly round trips to/from overseas port for the fall pipe vessel.
   155 total trips for barges and associated tugs.
   19 round trips from overseas port to Portsmouth for the semi-submersible monopile transport vessel.
   15 round trips from overseas port to Portsmouth for the deck carrier monopile/transition piece transport vessel.
   1 round trip to/from overseas port for the heavy lift vessel and jack-up vessel.
   2 total trips for each noise mitigation vessel.
   Weekly round trips for the secondary works 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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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 or VOC emissions from the CMVs.
   The HAP 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Foundation Construction Emissions

																		Total Emissions (Transit)										
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**	**Assumed fuel rate (kg per vessel per day)**	**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 Hours (hrs)**	**Transit Average load (%)**	**Non-Transit Average load (%)**	**Transit Fuel Usage Gallons (per vessel)**	**Non-Transit Fuel Usage Gallons (per vessel)**	**VOC tons**	**NO_x tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Fall Pipe Vessel - Scour protection installation		1	507 x 92 x 44 (26)																									
-Main Generators	2			3	5,147	Diesel	25,000	3.18	163	6	0	1139	24	27,336	38%	38%	320,362	8,954,403	1.57	41.54	3.46	0.58	0.57	1.25	0.14	2,033.42	1.26E-02	0.10	2,062.81
-Main Generators	2			2	3,861	Diesel			163	6	0	1139	24	27,336	38%	38%			1.18	23.13	11.80	1.46	1.42	0.02	0.13	1,628.74	0.21	0.05	1,648.12
Crew Transfer Vessel		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	8,000	3.18	292	12	0	583	24	13,992	85%	85%	367,296	1,466,667	1.56	56.44	28.80	1.49	1.44	0.04	0.16	3,974.05	0.52	0.12	4,021.34
-Aux. Generator	1			1	47	Diesel			292	12	0	583	24	13,992	85%	85%			0.03	1.13	0.58	0.03	0.03	7.56E-04	3.14E-03	79.82	1.04E-02	2.31E-03	80.77
-Aux. Engine	1			1	47	Diesel			292	12	0	583	24	13,992	85%	85%			0.03	1.13	0.58	0.03	0.03	7.56E-04	3.14E-03	79.82	1.04E-02	2.31E-03	80.77
Tug 1 for MP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	103	12	0	290	24	6,960	18%	18%	129,560	729,560	1.00	19.59	9.99	1.24	1.20	1.31E-02	0.11	1,379.11	0.18	0.04	1,395.52
-Harbor Generator	1			1	456	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 2 for MP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	103	12	0	290	24	6,960	18%	18%	129,560	729,560	1.00	19.59	9.99	1.24	1.20	1.31E-02	0.11	1,379.11	0.18	0.04	1,395.52
-Harbor Generator	1			1	456	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 3 for MP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	103	12	0	290	24	6,960	18%	18%	129,560	729,560	1.00	19.59	9.99	1.24	1.20	1.31E-02	0.11	1,379.11	0.18	0.04	1,395.52
-Harbor Generator	1			1	456	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 4 for MP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	103	12	0	290	24	6,960	18%	18%	129,560	729,560	1.00	19.59	9.99	1.24	1.20	1.31E-02	0.11	1,379.11	0.18	0.04	1,395.52
-Harbor Generator	1			1	456	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			103	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 1 for TP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	52	12	0	290	24	6,960	18%	18%	65,409	729,560	0.50	9.89	5.05	0.62	0.61	6.60E-03	0.05	696.25	0.09	0.02	704.53
-Harbor Generator	1			1	456	Diesel			52	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			52	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 2 for TP Barges		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	52	12	0	290	24	6,960	18%	18%	65,409	729,560	0.50	9.89	5.05	0.62	0.61	6.60E-03	0.05	696.25	0.09	0.02	704.53
-Harbor Generator	1			1	456	Diesel			52	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			52	12	0	290	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
MP Barges 1 through 4		N/A	400 x 105 x 20 (20)	N/A	N/A	N/A	0	N/A																				
TP Barges 1 through 2		N/A	250 x 70 x 15 (15)	N/A	N/A	N/A	0	N/A																				
Semi-Submersible - MP Transport		N/A	732 x 146 x 43 (33)																									
-Main Generators	2			3	26,300	Diesel	45,000	3.18	19	6	38	0	24	912	24%	24%	67,217	537,736	0.60	15.90	1.32	0.22	0.22	0.48	0.05	778.18	4.82E-03	0.04	789.43
Deck Carrier - MP/TP Transport		N/A	534 x 138 x 39 (18)																									
-Main Generators	2			2	3,861	Diesel	25,000	3.18	15	6	30	0	24	720	72%	72%	29,481	235,849	0.21	4.02	2.05	0.25	0.25	2.68E-03	0.02	282.96	0.04	0.01	286.33
-Aux. Generator	1			2	1,332	Diesel			15	6	30	0	24	720	72%	72%			0.04	0.69	0.35	0.04	0.04	4.63E-04	3.76E-03	48.83	6.37E-03	1.42E-03	49.41
-Emergency Generator	1			2	1,332	Diesel			0	6	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 1 for Port Maneuvering		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	0	0	290	0	24	6,960	0%	18%	0	729,560	0	0	0	0	0	0	0	0	0	0	0
-Harbor Generator	1			1	456	Diesel			0	0	290	0	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			0	0	290	0	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Tug 2 for Port Maneuvering		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	0	0	290	0	24	6,960	0%	18%	0	729,560	0	0	0	0	0	0	0	0	0	0	0
-Harbor Generator	1			1	456	Diesel			0	0	290	0	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			0	0	290	0	24	6,960	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel - MP & TP installation		1	710 x 161 x 55 (36)																									
-Main Engines	4			3	13,814	Diesel	45,000	3.18	1	6	0	387	24	9,288	22%	22%	3,538	5,476,415	0.03	0.79	0.07	1.11E-02	1.08E-02	0.02	2.64E-03	38.67	2.39E-04	1.86E-03	39.23
-Aux. Generators	2			2	1,488	Diesel			1	6	0	387	24	9,288	22%	22%			1.61E-03	0.03	0.02	2.00E-03	1.94E-03	2.11E-05	1.71E-04	2.22	2.90E-04	6.45E-05	2.25
Noise mitigation vessel 1		N/A	292 x 64 x 24.5 (20)																									
-Main Engines	4			2	2,446	Diesel	10,000	3.18	2	12	0	267	24	6,408	27%	27%	3,145	839,623	0.03	0.50	0.26	0.03	0.03	3.35E-04	2.72E-03	35.39	4.62E-03	1.03E-03	35.81
Noise mitigation vessel 2		N/A	292 x 64 x 24.5 (20)																									
-Main Engines	4			2	2,446	Diesel	10,000	3.18	2	12	0	267	24	6,408	27%	27%	3,145	839,623	0.03	0.50	0.26	0.03	0.03	3.35E-04	2.72E-03	35.39	4.62E-03	1.03E-03	35.81
Jack-up Vessel 1 - TP installation		3	434 x 128 x 30																									
-Main Engines	4			3	4,048	Diesel	20,000	3.18	1	6	0	473	24	11,352	35%	35%	1,572	2,974,843	1.41E-02	0.37	0.03	5.22E-03	5.06E-03	1.12E-02	1.24E-03	18.20	1.13E-04	8.73E-04	18.47
Jack-up Vessel 2 - TP installation		3	434 x 128 x 30																									
-Main Engines	4			3	4,048	Diesel	20,000	3.18	1	6	0	473	24	11,352	35%	35%	1,572	2,974,843	1.41E-02	0.37	0.03	5.22E-03	5.06E-03	1.12E-02	1.24E-03	18.20	1.13E-04	8.73E-04	18.47
Secondary works vessel		N/A	292 x 64 x 24.5 (20)																									
-Main Engines	4			2	2,446	Diesel	15,000	3.18	66	12	0	463	24	11,112	40%	40%	155,660	2,183,962	1.27	24.88	12.69	1.57	1.52	0.02	0.13	1,751.87	0.23	0.05	1,772.71
																	TOTALS		**1,602,044**	**32,320,440**	**11.60**	**269.58**	**112.36**	**11.97**	**11.61**	**1.91**	**1.18**	**17,715**	**1.95**	**0.57**	**17,933**

Notes:
1. Foundation installation is assumed to occur from October 2023 through November 2025.
2. Non-transit construction emissions 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 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of OCS lease area: 60 nm (VA state waters: 30 nm; OCS radius: 30 nm)
   Overseas port to center of OCS lease area: 30 nm (only includes portion of transit within 25 nm of the OCS lease area)
4. The number of transits for each vessel are based on the following assumptions:
   Weekly round trips to/from overseas port for the fall pipe vessel.
   155 total trips for barges and associated tugs.
   19 round trips from overseas port to Portsmouth for the semi-submersible monopile transport vessel.
   15 round trips from overseas port to Portsmouth for the deck carrier monopile/transition piece transport vessel.
   1 round trip to/from overseas port for the heavy lift vessel and jack-up vessel.
   2 total trips for each noise mitigation vessel.
   Weekly round trips for the secondary works 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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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 or VOC emissions from the CMVs.
   The HAP 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
OSS Jacket 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Non-Transit)									
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Deck Carrier/Semi-Submersible - Jacket Transport	2	1	571 x 131 x 34 (57)	3	4,826	Diesel	30,000	3.18	3	177	0	20	24	480	89%	89%	208,726	188,679	1.69	44.63	3.72	0.63	0.61	1.34	0.15	2,184.37	1.35E-02	0.10	2,215.94
Heavy Lift Vessel - Jacket installation		1	710 x 161 x 55 (36)																										
-Main Engines	4			3	13,814	Diesel	65,000	3.18	3	6	0	60	24	1,440	32%	32%	15,330	1,226,415	10.37	273.88	22.82	3.84	3.73	8.23	0.92	13,405.22	0.08	0.64	13,598.97
-Aux. Generators	2			2	1,488	Diesel			3	6	0	60	24	1,440	32%	32%			0.56	10.95	5.59	0.69	0.67	7.31E-03	0.06	771.05	0.10	0.02	780.22
																TOTALS	**224,057**	**1,415,094**	**12.62**	**329.46**	**32.13**	**5.16**	**5.01**	**9.58**	**1.12**	**16,360.63**	**0.20**	**0.77**	**16,595.13**

Notes:
1. OSS jacket installation is assumed to occur from November 2024 through April 2025.
2. Non-transit construction emissions 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 10 knots for all vessel types, and the following one-way travel distances:
   Texas port to center of OCS lease area: 1,770 nm (30 nm in TX state waters, 1,710 nm in non-OCS federal waters, and 30 nm within OCS radius)
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 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)
4. The number of transits for each vessel are based on the following assumptions:
   1 single-way trip from Texas port for the jacket transport vessel (per OSS).
   1 round trip to/from overseas port for the heavy lift vessel (per OSS).
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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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_{10} or VOC emissions from the CMVs.
   The HAP 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
OSS Jacket Installation Emissions

																		Total Emissions (Transit)									
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**	**Assumed fuel rate (kg per vessel per day)**	**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 Hours (hrs)**	**Transit Average load (%)**	**Non-Transit Average load (%)**	**Transit Fuel Usage Gallons (per vessel)**	**Non-Transit Fuel Usage Gallons (per vessel)**	**VOC tons**	**NO_x tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Deck Carrier/Semi-Submersible - Jacket Transport	2	1	571 x 131 x 34 (57)	3	4,826	Diesel	30,000	3.18	3	177	0	20	24	480	89%	89%	208,726	188,679	1.87	49.37	4.11	0.69	0.67	1.48	0.17	2416.45	1.50E-02	0.12	2,451.38
Heavy Lift Vessel - Jacket installation		1	710 x 161 x 55 (36)																										
-Main Engines	4			3	13,814	Diesel	65,000	3.18	3	6	0	60	24	1,440	32%	32%	15,330	1,226,415	0.13	3.42	0.29	0.05	0.05	0.10	1.15E-02	167.57	1.04E-03	8.04E-03	169.99
-Aux. Generators	2			2	1,488	Diesel			3	6	0	60	24	1,440	32%	32%			6.98E-03	0.14	0.07	8.65E-03	8.39E-03	9.13E-05	7.42E-04	9.64	1.26E-03	2.79E-04	9.75
																TOTALS	**224,057**	**1,415,094**	**2.01**	**52.93**	**4.47**	**0.75**	**0.73**	**1.59**	**0.18**	**2,593.66**	**1.73E-02**	**0.12**	**2,631.12**

Notes:
1. OSS jacket installation is assumed to occur from November 2024 through April 2025.
2. Non-transit construction emissions 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 10 knots for all vessel types, and the following one-way travel distances:
   Texas port to center of OCS lease area: 1,770 nm (30 nm in TX state waters, 1,710 nm in non-OCS federal waters, and 30 nm within OCS radius)
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 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)
4. The number of transits for each vessel are based on the following assumptions:
   1 single-way trip from Texas port for the jacket transport vessel (per OSS).
   1 round trip to/from overseas port for the heavy lift vessel (per OSS).
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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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_{10} or VOC emissions from the CMVs.
   The HAP 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
OSS Topside 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Non-Transit)									
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Deck Carrier/Semi-Submersible - Topside Transport	2	1	571 x 131 x 34 (57)	3	4,826	Diesel	30,000	3.18	3	177	0	20	24	480	89%	89%	208,726	188,679	1.69	44.63	3.72	0.63	0.61	1.34	0.15	2,184.37	1.35E-02	0.10	2,215.94
Semi-Submersible HLV - Topside Installation	12	1	721 x 334 x 162 (104)	3	10,724	Diesel	70,000	3.18	3	6	0	60	24	1,440	16%	16%	16,509	1,320,755	11.83	312.40	26.03	4.39	4.25	9.39	1.05	15,290.56	0.09	0.73	15,511.56
Jack-up Vessel - OSS Commissioning 1	6	3	455 x 134 x 33 (18)	2	3,552	Diesel	5,000	3.18	3	6	0	240	24	5,760	6%	6%	1,179	377,358	3.08	60.32	30.77	3.81	3.70	0.04	0.33	4,246.95	0.55	0.12	4,297.48
Jack-up Vessel - OSS Commissioning 2	6	3	455 x 134 x 33 (18)	2	3,552	Diesel	5,000	3.18	3	6	0	240	24	5,760	6%	6%	1,179	377,358	3.08	60.32	30.77	3.81	3.70	0.04	0.33	4,246.95	0.55	0.12	4,297.48
																TOTALS	**227,594**	**2,264,151**	**19.68**	**477.67**	**91.30**	**12.63**	**12.26**	**10.81**	**1.85**	**25,968.82**	**1.22**	**1.08**	**26,322.45**

Notes:
1. OSS topside installation and commissioning is assumed to occur from November 2024 through July 2025.
2. Non-transit construction emissions 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 10 knots for all 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)
   Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
4. The number of transits for each vessel are based on the following assumptions:
   1 single-way trip from Texas port for the topside transport vessel (per OSS).
   1 round trip to/from overseas port for the topside installation vessel and commissioning vessels (per OSS).
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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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_{10} or VOC emissions from the CMVs.
   The HAP 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
OSS Topside 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Transit)									
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Deck Carrier/Semi-Submersible - Topside Transport	2	1	571 x 131 x 34 (57)	3	4,826	Diesel	30,000	3.18	3	177	0	20	24	480	89%	89%	208,726	188,679	1.87	49.37	4.11	0.69	0.67	1.48	0.17	2416.45	1.50E-02	0.12	2,451.38
Semi-Submersible HLV - Topside Installation	12	1	721 x 334 x 162 (104)	3	10,724	Diesel	70,000	3.18	3	6	0	60	24	1,440	16%	16%	16,509	1,320,755	0.15	3.90	0.33	0.05	0.05	0.12	1.31E-02	191.13	1.18E-03	9.17E-03	193.89
Jack-up Vessel - OSS Commissioning 1	6	3	455 x 134 x 33 (18)	2	3,552	Diesel	5,000	3.18	3	6	0	240	24	5,760	6%	6%	1,179	377,358	9.62E-03	0.19	0.10	1.19E-02	1.16E-02	1.26E-04	1.02E-03	13.27	1.73E-03	3.85E-04	13.43
Jack-up Vessel - OSS Commissioning 2	6	3	455 x 134 x 33 (18)	2	3,552	Diesel	5,000	3.18	3	6	0	240	24	5,760	6%	6%	1,179	377,358	9.62E-03	0.19	0.10	1.19E-02	1.16E-02	1.26E-04	1.02E-03	13.27	1.73E-03	3.85E-04	13.43
																TOTALS	227,594	2,264,151	2.04	53.65	4.63	0.77	0.75	1.60	0.18	2,634.13	1.96E-02	0.13	2,672.13

Notes:
1. OSS topside installation and commissioning is assumed to occur from November 2024 through July 2025.
2. Non-transit construction emissions 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 10 knots for all 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)
   Overseas port to center of OCS lease area: 30.0 nm (only includes portion of transit within 25 nm of the OCS lease area)
4. The number of transits for each vessel are based on the following assumptions:
   1 single-way trip from Texas port for the topside transport vessel (per OSS).
   1 round trip to/from overseas port for the topside installation vessel and commissioning vessels (per OSS).
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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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_{10} or VOC emissions from the CMVs.
   The HAP 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Nearshore Export 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Non-Transit)								
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Cable Lay Vessel		N/A	401 x 110 x 25 (18)																								
-Main Generators	4			2	1,332	Diesel	20,000	3.18	1	0.5	176	0	24	4,224	98%	89%	131	1,106,918	8.20	160.76	82.02	10.16	9.85	0.11	0.87	11,318.98	1.48	0.33	11,453.66
-Crane Engine	1			1	536	Diesel			0	0	176	0	24	4,224	0%	89%			0.45	16.17	8.25	0.43	0.41	1.08E-02	0.04	1,138.73	0.15	0.03	1,152.28
-Emergency Generator	1			1	361	Diesel			0	0	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Shore Pull-In Tug 1		N/A	136 x 36 x 19 (17)																								
-Main Engines	2			2	3,600	Diesel	5,000	3.18	25	7	176	0	24	4,224	18%	18%	11,465	276,730	2.20	43.10	21.99	2.72	2.64	0.03	0.23	3,034.35	0.40	0.09	3,070.46
-Aux. Engines	2			1	95	Diesel			25	7	176	0	24	4,224	18%	18%			0.03	1.14	0.58	0.03	0.03	7.59E-04	3.15E-03	80.07	1.04E-02	2.32E-03	81.03
Shore Pull-In Tug 2		N/A	136 x 36 x 19 (17)																								
-Main Engines	2			2	3,600	Diesel	5,000	3.18	25	7	176	0	24	4,224	18%	18%	11,465	276,730	2.20	43.10	21.99	2.72	2.64	0.03	0.23	3,034.35	0.40	0.09	3,070.46
-Aux. Engines	2			1	95	Diesel			25	7	176	0	24	4,224	18%	18%			0.03	1.14	0.58	0.03	0.03	7.59E-04	3.15E-03	80.07	1.04E-02	2.32E-03	81.03
Shore Pull-In Barge		N/A	180 x 60 x 6 (6)	N/A	N/A	N/A	0	N/A																				
Pre-Lay Grapnel Run Vessel		N/A	150 x 36 x 10																								
-Main Engines	2			1	750	Diesel	6,000	3.18	7	7	47	0	24	1,128	95%	75%	3,852	88,679	0.28	10.17	5.19	0.27	0.26	6.78E-03	0.03	715.95	0.09	0.02	724.47
-Aux. Generator	1			1	133	Diesel			7	7	47	0	24	1,128	95%	75%			0.02	0.90	0.46	0.02	0.02	6.02E-04	2.49E-03	63.48	8.28E-03	1.84E-03	64.24
-Bow Thruster Engine	1			1	325	Diesel			0	0	47	0	24	1,128	0%	75%			0.06	2.20	1.12	0.06	0.06	1.47E-03	6.09E-03	155.12	0.02	4.50E-03	156.97
-Aux. Engine	1			1	133	Diesel			0	0	47	0	24	1,128	0%	75%			0.02	0.90	0.46	0.02	0.02	6.02E-04	2.49E-03	63.48	8.28E-03	1.84E-03	64.24
Pre-Installation Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	2	7	16	0	24	384	43%	43%	734	20,126	0.09	3.09	1.58	0.08	0.08	2.06E-03	8.55E-03	217.76	0.03	6.31E-03	220.35
-Aux. Generator	1			1	47	Diesel			2	7	16	0	24	384	43%	43%			1.71E-03	0.06	0.03	1.64E-03	1.59E-03	4.14E-05	1.72E-04	4.37	5.70E-04	1.27E-04	4.43
-Aux. Engine	1			1	47	Diesel			2	7	16	0	24	384	43%	43%			1.71E-03	0.06	0.03	1.64E-03	1.59E-03	4.14E-05	1.72E-04	4.37	5.70E-04	1.27E-04	4.43
As-Built Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	2	7	16	0	24	384	43%	43%	734	20,126	0.09	3.09	1.58	0.08	0.08	2.06E-03	8.55E-03	217.76	0.03	6.31E-03	220.35
-Aux. Generator	1			1	47	Diesel			2	7	16	0	24	384	43%	43%			1.71E-03	0.06	0.03	1.64E-03	1.59E-03	4.14E-05	1.72E-04	4.37	5.70E-04	1.27E-04	4.43
-Aux. Engine	1			1	47	Diesel			2	7	16	0	24	384	43%	43%			1.71E-03	0.06	0.03	1.64E-03	1.59E-03	4.14E-05	1.72E-04	4.37	5.70E-04	1.27E-04	4.43
Crew Transfer Vessel 1		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	88	7	176	0	24	4,224	85%	85%	64,570	442,767	1.87	68.04	34.71	1.79	1.74	0.05	0.19	4,790.64	0.62	0.14	4,847.64
-Aux. Generator	1			1	47	Diesel			88	7	176	0	24	4,224	85%	85%			0.04	1.37	0.70	0.04	0.03	9.12E-04	3.78E-03	96.22	1.26E-02	2.79E-03	97.37
-Aux. Engine	1			1	47	Diesel			88	7	176	0	24	4,224	85%	85%			0.04	1.37	0.70	0.04	0.03	9.12E-04	3.78E-03	96.22	1.26E-02	2.79E-03	97.37
Crew Transfer Vessel 2		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	88	7	176	0	24	4,224	85%	85%	64,570	442,767	1.87	68.04	34.71	1.79	1.74	0.05	0.19	4,790.64	0.62	0.14	4,847.64
-Aux. Generator	1			1	47	Diesel			88	7	176	0	24	4,224	85%	85%			0.04	1.37	0.70	0.04	0.03	9.12E-04	3.78E-03	96.22	1.26E-02	2.79E-03	97.37
-Aux. Engine	1			1	47	Diesel			88	7	176	0	24	4,224	85%	85%			0.04	1.37	0.70	0.04	0.03	9.12E-04	3.78E-03	96.22	1.26E-02	2.79E-03	97.37
																TOTALS	157,521	2,674,843	**17.58**	**427.56**	**218.14**	**20.36**	**19.75**	**0.29**	**1.84**	**30,104**	**3.93**	**0.87**	**30,462**

Notes:

1. Nearshore export cable installation is assumed to occur from December 2023 through February 2024, and from September through December 2024.
2. All nearshore export cable construction is assumed to occur in Virginia state waters (within 3 nm from shore).
3. Non-transit construction emissions were estimated based on the number of days of operation provided by the project.
4. Transit emissions are based on an assumed vessel speed of 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of nearshore cable corridor: 35 nm (State waters: 35 nm; OCS radius: 0 nm)
   Overseas port to center of nearshore cable corridor: 1.5 nm (only includes portion of transit within state waters)
5. The number of transits for each vessel are based on the following assumptions:
   1 round trip to/from overseas port for export cable lay vessel.
   Weekly round trips to/from local port for pre-lay grapnel run vessel, tugs and barge, and survey vessels.
   Every other day for crew transfer vessels.
6. 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.
7. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
8. HAP 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 or VOC emissions from the CMVs.
   The HAP 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. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Nearshore Export 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Transit)								
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Cable Lay Vessel		N/A	401 x 110 x 25 (18)																								
-Main Generators	4			2	1,332	Diesel	20,000	3.18	1	0.5	176	0	24	4,224	98%	89%	131	1,106,918	1.07E-03	0.02	0.01	0.00	0.00	1.40E-05	1.13E-04	1.47	1.92E-04	4.27E-05	1.49
-Crane Engine	1			1	536	Diesel			0	0	176	0	24	4,224	0%	89%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	361	Diesel			0	0	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Shore Pull-In Tug 1		N/A	136 x 36 x 19 (17)																								
-Main Engines	2			2	3,600	Diesel	5,000	3.18	25	7	176	0	24	4,224	18%	18%	11,465	276,730	0.09	1.79	0.91	0.11	0.11	1.19E-03	0.01	125.71	0.02	3.64E-03	127.21
-Aux. Engines	2			1	95	Diesel			25	7	176	0	24	4,224	18%	18%			1.30E-03	0.05	0.02	1.24E-03	1.20E-03	3.14E-05	1.30E-04	3.32	4.33E-04	9.62E-05	3.36
Shore Pull-In Tug 2		N/A	136 x 36 x 19 (17)																								
-Main Engines	2			2	3,600	Diesel	5,000	3.18	25	7	176	0	24	4,224	18%	18%	11,465	276,730	0.09	1.79	0.91	0.11	0.11	1.19E-03	0.01	125.71	0.02	3.64E-03	127.21
-Aux. Engines	2			1	95	Diesel			25	7	176	0	24	4,224	18%	18%			1.30E-03	0.05	0.02	1.24E-03	1.20E-03	3.14E-05	1.30E-04	3.32	4.33E-04	9.62E-05	3.36
Shore Pull-In Barge		N/A	180 x 60 x 6 (6)	N/A	N/A	N/A	0	N/A																					
Pre-Lay Grapnel Run Vessel		N/A	150 x 36 x 10																								
-Main Engines	2			1	750	Diesel	6,000	3.18	7	7	47	0	24	1,128	95%	75%	3,852	88,679	0.02	0.57	0.29	0.01	0.01	3.77E-04	1.56E-03	39.82	5.19E-03	1.15E-03	40.30
-Aux. Generator	1			1	133	Diesel			7	7	47	0	24	1,128	95%	75%			1.38E-03	0.05	0.03	1.32E-03	1.28E-03	3.35E-05	1.39E-04	3.53	4.61E-04	1.02E-04	3.57
-Bow Thruster Engine	1			1	325	Diesel			0	0	47	0	24	1,128	0%	75%			0	0	0	0	0	0	0	0	0	0	0
-Aux. Engine	1			1	133	Diesel			0	0	47	0	24	1,128	0%	75%			0	0	0	0	0	0	0	0	0	0	0
Pre-Installation Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	2	7	16	0	24	384	43%	43%	734	20,126	3.11E-03	0.11	0.06	2.97E-03	2.88E-03	7.52E-05	3.12E-04	7.94	1.04E-03	2.30E-04	8.03
-Aux. Generator	1			1	47	Diesel			2	7	16	0	24	384	43%	43%			6.24E-05	2.26E-03	1.16E-03	5.96E-05	5.78E-05	1.51E-06	6.26E-06	0.16	2.08E-05	4.62E-06	0.16
-Aux. Engine	1			1	47	Diesel			2	7	16	0	24	384	43%	43%			6.24E-05	2.26E-03	1.16E-03	5.96E-05	5.78E-05	1.51E-06	6.26E-06	0.16	2.08E-05	4.62E-06	0.16
As-Built Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	2	7	16	0	24	384	43%	43%	734	20,126	3.11E-03	0.11	0.06	2.97E-03	2.88E-03	7.52E-05	3.12E-04	7.94	1.04E-03	2.30E-04	8.03
-Aux. Generator	1			1	47	Diesel			2	7	16	0	24	384	43%	43%			6.24E-05	2.26E-03	1.16E-03	5.96E-05	5.78E-05	1.51E-06	6.26E-06	0.16	2.08E-05	4.62E-06	0.16
-Aux. Engine	1			1	47	Diesel			2	7	16	0	24	384	43%	43%			6.24E-05	2.26E-03	1.16E-03	5.96E-05	5.78E-05	1.51E-06	6.26E-06	0.16	2.08E-05	4.62E-06	0.16
Crew Transfer Vessel 1		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	88	7	176	0	24	4,224	85%	85%	64,570	442,767	0.27	9.92	5.06	0.26	0.25	6.62E-03	0.03	698.63	0.09	0.02	706.95
-Aux. Generator	1			1	47	Diesel			88	7	176	0	24	4,224	85%	85%			5.49E-03	0.20	0.10	5.25E-03	5.09E-03	1.33E-04	5.51E-04	14.03	1.83E-03	4.07E-04	14.20
-Aux. Engine	1			1	47	Diesel			88	7	176	0	24	4,224	85%	85%			5.49E-03	0.20	0.10	5.25E-03	5.09E-03	1.33E-04	5.51E-04	14.03	1.83E-03	4.07E-04	14.20
Crew Transfer Vessel 2		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	88	7	176	0	24	4,224	85%	85%	64,570	442,767	0.27	9.92	5.06	0.26	0.25	6.62E-03	0.03	698.63	0.09	0.02	706.95
-Aux. Generator	1			1	47	Diesel			88	7	176	0	24	4,224	85%	85%			5.49E-03	0.20	0.10	5.25E-03	5.09E-03	1.33E-04	5.51E-04	14.03	1.83E-03	4.07E-04	14.20
-Aux. Engine	1			1	47	Diesel			88	7	176	0	24	4,224	85%	85%			5.49E-03	0.20	0.10	5.25E-03	5.09E-03	1.33E-04	5.51E-04	14.03	1.83E-03	4.07E-04	14.20
																TOTALS	**157,521**	**2,674,843**	**0.78**	**25.18**	**12.85**	**0.80**	**0.77**	**0.02**	**0.08**	**1,773**	**0.23**	**0.05**	**1,794**

Notes:

1. Nearshore export cable installation is assumed to occur from December 2023 through February 2024, and from September through December 2024.
2. All nearshore export cable construction is assumed to occur in Virginia state waters (within 3 nm from shore).
3. Non-transit construction emissions were estimated based on the number of days of operation provided by the project.
4. Transit emissions are based on an assumed vessel speed of 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of nearshore cable corridor: 35 nm (State waters: 35 nm; OCS radius: 0 nm)
   Overseas port to center of nearshore cable corridor: 1.5 nm (only includes portion of transit within state waters)
5. The number of transits for each vessel are based on the following assumptions:
   1 round trip to/from overseas port for export cable lay vessel.
   Weekly round trips to/from local port for pre-lay grapnel run vessel, tugs and barge, and survey vessels.
   Every other day for crew transfer vessels.
6. 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.
7. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
8. HAP 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 or VOC emissions from the CMVs.
   The HAP 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. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Farshore Export 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Non-Transit)								
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Cable Lay Vessel		1	528 x 106 x 38																								
-Main Engines	2			3	5,791	Diesel	29,000	3.18	1	7	0	162	24	3,888	41%	41%	2,660	1,477,358	7.64	201.71	16.81	2.83	2.75	6.06	0.67	9,872.75	0.06	0.47	10,015.44
-Main Engines	2			2	3,861	Diesel			1	7	0	162	24	3,888	41%	41%			5.09	99.84	50.94	6.31	6.12	0.07	0.54	7,029.26	0.92	0.20	7,112.90
Walk-to-Work Vessel		1	354 x 52 x 31 (18)																								
-Main Generators	4			2	1,609	Diesel	10,000	3.18	1	7	0	63	24	1,512	35%	35%	917	198,113	1.38	27.14	13.85	1.72	1.66	0.02	0.15	1,911.13	0.25	0.06	1,933.87
-Aux. Generator	1			1	1,072	Diesel			1	7	0	63	24	1,512	35%	35%			0.12	4.52	2.31	0.12	0.12	3.02E-03	1.25E-02	318.52	0.04	9.23E-03	322.31
-Emergency Generator	1			1	201	Diesel			0	0	0	0	0	0	35%	35%			0	0	0	0	0	0	0	0	0	0	0
Trenching Support Vessel 1		1	426 x 72 x 36 (21)																								
-Main Generators	4			2	3,740	Diesel	15,000	3.18	1	7	0	243	24	5,832	26%	26%	1,376	1,146,226	9.35	183.22	93.48	11.58	11.23	0.12	0.99	12,900.10	1.68	0.37	13,053.59
-Emergency Generator	1			1	550	Diesel			0	0	0	0	0	0	26%	26%			0	0	0	0	0	0	0	0	0	0	0
Trenching Support Vessel 2		1	426 x 72 x 36 (21)																								
-Main Generators	4			2	3,740	Diesel	15,000	3.18	1	7	0	243	24	5,832	26%	26%	1,376	1,146,226	9.35	183.22	93.48	11.58	11.23	0.12	0.99	12,900.10	1.68	0.37	13,053.59
-Emergency Generator	1			1	550	Diesel			0	0	0	0	0	0	26%	26%			0	0	0	0	0	0	0	0	0	0	0
Pre-Lay Grapnel Run Vessel		N/A	150 x 36 x 10																								
-Main Engines	2			1	750	Diesel	6,000	3.18	7	8	0	47	24	1,128	95%	75%	4,403	88,679	0.28	10.17	5.19	0.27	0.26	6.78E-03	0.03	715.95	0.09	0.02	724.47
-Aux. Generator	1			1	133	Diesel			7	8	0	47	24	1,128	95%	75%			0.02	0.90	0.46	0.02	0.02	6.02E-04	2.49E-03	63.48	8.28E-03	1.84E-03	64.24
-Bow Thruster Engine	1			1	325	Diesel			0	0	0	47	24	1,128	0%	75%			0.06	2.20	1.12	0.06	0.06	1.47E-03	6.09E-03	155.12	2.02E-02	4.50E-03	156.97
-Aux. Engine	1			1	133	Diesel			0	0	0	47	24	1,128	0%	75%			0.02	0.90	0.46	0.02	0.02	6.02E-04	2.49E-03	63.48	8.28E-03	1.84E-03	64.24
Pre-Installation Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	3	8	0	24	24	576	43%	43%	1,258	30,189	0.13	4.64	2.37	0.12	0.12	3.10E-03	1.28E-02	326.63	0.04	9.47E-03	330.52
-Aux. Generator	1			1	47	Diesel			3	8	0	24	24	576	43%	43%			2.57E-03	0.09	0.05	2.45E-03	2.38E-03	6.22E-05	2.58E-04	6.56	8.56E-04	1.90E-04	6.64
-Aux. Engine	1			1	47	Diesel			3	8	0	24	24	576	43%	43%			2.57E-03	0.09	0.05	2.45E-03	2.38E-03	6.22E-05	2.58E-04	6.56	8.56E-04	1.90E-04	6.64
As-Built Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	3	8	0	24	24	576	43%	43%	1,258	30,189	0.13	4.64	2.37	0.12	0.12	3.10E-03	1.28E-02	326.63	0.04	9.47E-03	330.52
-Aux. Generator	1			1	47	Diesel			3	8	0	24	24	576	43%	43%			2.57E-03	0.09	0.05	2.45E-03	2.38E-03	6.22E-05	2.58E-04	6.56	8.56E-04	1.90E-04	6.64
-Aux. Engine	1			1	47	Diesel			3	8	0	24	24	576	43%	43%			2.57E-03	0.09	0.05	2.45E-03	2.38E-03	6.22E-05	2.58E-04	6.56	8.56E-04	1.90E-04	6.64
Crew Transfer Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	32	8	0	63	24	1,512	85%	85%	26,834	158,491	0.67	24.36	12.43	0.64	0.62	0.02	0.07	1,714.83	0.22	0.05	1,735.24
-Aux. Generator	1			1	47	Diesel			32	8	0	63	24	1,512	85%	85%			1.35E-02	0.49	0.25	1.29E-02	1.25E-02	3.26E-04	1.35E-03	34.44	4.49E-03	9.98E-04	34.85
-Aux. Engine	1			1	47	Diesel			32	8	0	63	24	1,512	85%	85%			1.35E-02	0.49	0.25	1.29E-02	1.25E-02	3.26E-04	1.35E-03	34.44	4.49E-03	9.98E-04	34.85
																TOTALS	40,081	4,275,472	34.29	748.81	295.94	35.42	34.36	6.43	3.50	48,393	5.09	1.59	48,994

Notes:

1. Farshore export cable installation is assumed to occur from October 2024 - January 2025, April - July 2025, and November 2025 - February 2026.
2. All farshore export cable construction is assumed to occur in federal waters within 25 nm of the OCS lease area.
3. Non-transit construction emissions were estimated based on the number of days of operation provided by the project.
4. Transit emissions are based on an assumed vessel speed of 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of farshore cable corridor: 42 nm (State waters: 30 nm; OCS radius: 12 nm)
   Overseas port to center of farshore cable corridor: 35 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 overseas port for export cable lay vessel, walk-to-work vessels, and trenching support vessels.
   Weekly round trips to/from local port for pre-lay grapnel run vessel and survey vessels.
   Every other day for the crew transfer vessel.
6. 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.
7. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
8. HAP 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 or VOC emissions from the CMVs.
   The HAP 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. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Farshore Export 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Transit)								
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Cable Lay Vessel		1	528 x 106 x 38																								
-Main Engines	2			3	5,791	Diesel	29,000	3.18	1	7	0	162	24	3,888	41%	41%	2,660	1,477,358	1.38E-02	0.36	0.03	5.10E-03	4.95E-03	1.09E-02	1.21E-03	17.78	1.10E-04	8.53E-04	18.03
-Main Engines	2			2	3,861	Diesel			1	7	0	162	24	3,888	41%	41%			9.17E-03	0.18	0.09	1.14E-02	1.10E-02	1.20E-04	9.74E-04	12.66	1.65E-03	3.67E-04	12.81
Walk-to-Work Vessel		1	354 x 52 x 31 (18)																								
-Main Generators	4			2	1,609	Diesel	10,000	3.18	1	7	0	63	24	1,512	35%	35%	917	198,113	6.41E-03	0.13	0.06	7.94E-03	7.70E-03	8.38E-05	6.81E-04	8.85	1.15E-03	2.56E-04	8.95
-Aux. Generator	1			1	1,072	Diesel			1	7	0	63	24	1,512	35%	35%			5.77E-04	0.02	1.07E-02	5.51E-04	5.35E-04	1.40E-05	5.79E-05	1.47	1.92E-04	4.27E-05	1.49
-Emergency Generator	1			1	201	Diesel			0	0	0	0	0	0	35%	35%			0	0	0	0	0	0	0	0	0	0	0
Trenching Support Vessel 1		1	426 x 72 x 36 (21)																								
-Main Generators	4			2	3,740	Diesel	15,000	3.18	1	7	0	243	24	5,832	26%	26%	1,376	1,146,226	1.12E-02	0.22	0.11	1.39E-02	1.35E-02	1.47E-04	1.19E-03	15.48	2.02E-03	4.49E-04	15.67
-Emergency Generator	1			1	550	Diesel			0	0	0	0	0	0	26%	26%			0	0	0	0	0	0	0	0	0	0	0
Trenching Support Vessel 2		1	426 x 72 x 36 (21)																								
-Main Generators	4			2	3,740	Diesel	15,000	3.18	1	7	0	243	24	5,832	26%	26%	1,376	1,146,226	1.12E-02	0.22	0.11	1.39E-02	1.35E-02	1.47E-04	1.19E-03	15.48	2.02E-03	4.49E-04	15.67
-Emergency Generator	1			1	550	Diesel			0	0	0	0	0	0	26%	26%			0	0	0	0	0	0	0	0	0	0	0
Pre-Lay Grapnel Run Vessel		N/A	150 x 36 x 10																								
-Main Engines	2			1	750	Diesel	6,000	3.18	7	8	0	47	24	1,128	95%	75%	4,403	88,679	0.02	0.65	0.33	0.02	0.02	4.31E-04	1.79E-03	45.51	5.94E-03	1.32E-03	46.05
-Aux. Generator	1			1	133	Diesel			7	8	0	47	24	1,128	95%	75%			1.58E-03	0.06	0.03	1.51E-03	1.46E-03	3.82E-05	1.59E-04	4.04	5.26E-04	1.17E-04	4.08
-Bow Thruster Engine	1			1	325	Diesel			0	0	0	47	24	1,128	0%	75%			0	0	0	0	0	0	0	0	0	0	0
-Aux. Engine	1			1	133	Diesel			0	0	0	47	24	1,128	0%	75%			0	0	0	0	0	0	0	0	0	0	0
Pre-Installation Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	3	8	0	24	24	576	43%	43%	1,258	30,189	5.33E-03	0.19	0.10	5.09E-03	4.94E-03	1.29E-04	5.35E-04	13.61	1.78E-03	3.94E-04	13.77
-Aux. Generator	1			1	47	Diesel			3	8	0	24	24	576	43%	43%			1.07E-04	3.88E-03	1.98E-03	1.02E-04	9.91E-05	2.59E-06	1.07E-05	0.27	3.57E-05	7.92E-06	0.28
-Aux. Engine	1			1	47	Diesel			3	8	0	24	24	576	43%	43%			1.07E-04	3.88E-03	1.98E-03	1.02E-04	9.91E-05	2.59E-06	1.07E-05	0.27	3.57E-05	7.92E-06	0.28
As-Built Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	3	8	0	24	24	576	43%	43%	1,258	30,189	5.33E-03	0.19	0.10	5.09E-03	4.94E-03	1.29E-04	5.35E-04	13.61	1.78E-03	3.94E-04	13.77
-Aux. Generator	1			1	47	Diesel			3	8	0	24	24	576	43%	43%			1.07E-04	3.88E-03	1.98E-03	1.02E-04	9.91E-05	2.59E-06	1.07E-05	0.27	3.57E-05	7.92E-06	0.28
-Aux. Engine	1			1	47	Diesel			3	8	0	24	24	576	43%	43%			1.07E-04	3.88E-03	1.98E-03	1.02E-04	9.91E-05	2.59E-06	1.07E-05	0.27	3.57E-05	7.92E-06	0.28
Crew Transfer Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	32	8	0	63	24	1,512	85%	85%	26,834	158,491	0.11	4.12	2.10	0.11	0.11	2.75E-03	0.01	290.34	0.04	8.42E-03	293.80
-Aux. Generator	1			1	47	Diesel			32	8	0	63	24	1,512	85%	85%			2.28E-03	0.08	0.04	2.18E-03	2.12E-03	5.53E-05	2.29E-04	5.83	7.61E-04	1.69E-04	5.90
-Aux. Engine	1			1	47	Diesel			32	8	0	63	24	1,512	85%	85%			2.28E-03	0.08	0.04	2.18E-03	2.12E-03	5.53E-05	2.29E-04	5.83	7.61E-04	1.69E-04	5.90
																TOTALS	**40,081**	**4,275,472**	**0.20**	**6.52**	**3.17**	**0.19**	**0.19**	**0.02**	**0.02**	**452**	**0.06**	**0.01**	**457**

Notes:

1. Farshore export cable installation is assumed to occur from October 2024 - January 2025, April - July 2025, and November 2025 - February 2026.
2. All farshore export cable construction is assumed to occur in federal waters within 25 nm of the OCS lease area.
3. Non-transit construction emissions were estimated based on the number of days of operation provided by the project.
4. Transit emissions are based on an assumed vessel speed of 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of farshore cable corridor: 42 nm (State waters: 30 nm; OCS radius: 12 nm)
   Overseas port to center of farshore cable corridor: 35 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 overseas port for export cable lay vessel, walk-to-work vessels, and trenching support vessels.
   Weekly round trips to/from local port for pre-lay grapnel run vessel and survey vessels.
   Every other day for the crew transfer vessel.
6. 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.
7. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
8. HAP 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 or VOC emissions from the CMVs.
   The HAP 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. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Inter-Array 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Non-Transit)								
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Cable Lay Vessel		1	528 x 106 x 38																								
-Main Engines	2			3	5,791	Diesel	29,000	3.18	1	6	0	190	24	4,560	41%	41%	2,280	1,732,704	8.96	236.57	19.71	3.32	3.22	7.11	0.79	11,579.15	0.07	0.56	11,746.51
-Main Engines	2			2	3,861	Diesel			1	6	0	190	24	4,560	41%	41%			5.97	117.09	59.74	7.40	7.18	0.08	0.63	8,244.20	1.08	0.24	8,342.29
Walk-to-Work Vessel		1	354 x 52 x 31 (18)																								
-Main Generators	4			2	1,609	Diesel	10,000	3.18	1	6	0	222	24	5,328	35%	35%	786	698,113	4.88	95.65	48.80	6.04	5.86	0.06	0.52	6,734.44	0.88	0.20	6,814.57
-Aux. Generator	1			1	1,072	Diesel			1	6	0	222	24	5,328	35%	35%			0.44	15.94	8.13	0.42	0.41	1.06E-02	0.04	1,122.41	0.15	0.03	1,135.76
-Emergency Generator	1			1	201	Diesel			0	0	0	0	0	0	35%	35%			0	0	0	0	0	0	0	0	0	0	0
Trenching Support Vessel 1		1	426 x 72 x 36 (21)																								
-Main Generators	4			2	3,740	Diesel	15,000	3.18	1	6	0	285	24	6,840	26%	26%	1,179	1,344,340	10.96	214.89	109.64	13.58	13.17	0.14	1.16	15,129.75	1.97	0.44	15,309.77
-Emergency Generator	1			1	550	Diesel			0	0	0	0	0	0	26%	26%			0	0	0	0	0	0	0	0	0	0	0
Trenching Support Vessel 2		1	426 x 72 x 36 (21)																								
-Main Generators	4			2	3,740	Diesel	15,000	3.18	1	6	0	285	24	6,840	26%	26%	1,179	1,344,340	10.96	214.89	109.64	13.58	13.17	0.14	1.16	15,129.75	1.97	0.44	15,309.77
-Emergency Generator	1			1	550	Diesel			0	0	0	0	0	0	26%	26%			0	0	0	0	0	0	0	0	0	0	0
Pre-Lay Grapnel Run Vessel		N/A	150 x 36 x 10																								
-Main Engines	2			1	750	Diesel	6,000	3.18	5	12	0	37	24	888	95%	75%	4,717	69,811	0.22	8.01	4.08	0.21	0.20	5.34E-03	0.02	563.62	0.07	0.02	570.33
-Aux. Generator	1			1	133	Diesel			5	12	0	37	24	888	95%	75%			0.02	0.71	0.36	0.02	0.02	4.74E-04	1.96E-03	49.97	6.52E-03	1.45E-03	50.57
-Bow Thruster Engine	1			1	325	Diesel			0	0	0	37	24	888	0%	75%			0.05	1.73	0.88	0.05	0.04	1.16E-03	4.80E-03	122.12	0.02	3.54E-03	123.57
-Aux. Engine	1			1	133	Diesel			0	0	0	37	24	888	0%	75%			0.02	0.71	0.36	0.02	0.02	4.74E-04	1.96E-03	49.97	6.52E-03	1.45E-03	50.57
Pre-Installation Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	4	12	0	27	24	648	43%	43%	2,516	33,962	0.14	5.22	2.66	0.14	0.13	3.48E-03	1.44E-02	367.46	0.05	1.07E-02	371.84
-Aux. Generator	1			1	47	Diesel			4	12	0	27	24	648	43%	43%			2.89E-03	0.10	0.05	2.76E-03	2.68E-03	6.99E-05	2.90E-04	7.38	9.63E-04	2.14E-04	7.47
-Aux. Engine	1			1	47	Diesel			4	12	0	27	24	648	43%	43%			2.89E-03	0.10	0.05	2.76E-03	2.68E-03	6.99E-05	2.90E-04	7.38	9.63E-04	2.14E-04	7.47
As-Built Survey Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	4,000	3.18	4	12	0	27	24	648	43%	43%	2,516	33,962	0.14	5.22	2.66	0.14	0.13	3.48E-03	1.44E-02	367.46	0.05	1.07E-02	371.84
-Aux. Generator	1			1	47	Diesel			4	12	0	27	24	648	43%	43%			2.89E-03	0.10	0.05	2.76E-03	2.68E-03	6.99E-05	2.90E-04	7.38	9.63E-04	2.14E-04	7.47
-Aux. Engine	1			1	47	Diesel			4	12	0	27	24	648	43%	43%			2.89E-03	0.10	0.05	2.76E-03	2.68E-03	6.99E-05	2.90E-04	7.38	9.63E-04	2.14E-04	7.47
Crew Transfer Vessel 1		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	84	12	0	167	24	4,008	85%	85%	105,660	420,126	1.78	64.56	32.94	1.70	1.65	0.04	0.18	4,545.66	0.59	0.13	4,599.75
-Aux. Generator	1			1	47	Diesel			84	12	0	167	24	4,008	85%	85%			0.04	1.30	0.66	0.03	0.03	8.65E-04	3.59E-03	91.30	1.19E-02	2.65E-03	92.39
-Aux. Engine	1			1	47	Diesel			84	12	0	167	24	4,008	85%	85%			0.04	1.30	0.66	0.03	0.03	8.65E-04	3.59E-03	91.30	1.19E-02	2.65E-03	92.39
Crew Transfer Vessel 2		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	84	12	0	167	24	4,008	85%	85%	105,660	420,126	1.78	64.56	32.94	1.70	1.65	0.04	0.18	4,545.66	0.59	0.13	4,599.75
-Aux. Generator	1			1	47	Diesel			84	12	0	167	24	4,008	85%	85%			0.04	1.30	0.66	0.03	0.03	8.65E-04	3.59E-03	91.30	1.19E-02	2.65E-03	92.39
-Aux. Engine	1			1	47	Diesel			84	12	0	167	24	4,008	85%	85%			0.04	1.30	0.66	0.03	0.03	8.65E-04	3.59E-03	91.30	1.19E-02	2.65E-03	92.39
																TOTALS	226,494	6,097,484	46.49	1,051.35	435.42	48.45	47.00	7.65	4.75	68,946	7.55	2.22	69,796

Notes:
1. Inter-array cable installation is assumed to occur from January - April 2025, July - November 2025, and February - May 2026.
2. Non-transit construction emissions 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 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 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)
4. The number of transits for each vessel are based on the following assumptions:
   1 round trip to/from overseas port for export cable lay vessel, walk-to-work vessel, and trenching support vessels.
   Weekly round trips to/from local port for pre-lay grapnel run vessel and survey vessels.
   Every other day for the crew transfer vessels.
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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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_{10} or VOC emissions from the CMVs.
   The HAP 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Inter-Array 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Transit)									
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Cable Lay Vessel		1	528 x 106 x 38																									
-Main Engines	2			3	5,791	Diesel	29,000	3.18	1	6	0	190	24	4,560	41%	41%	2,280	1,732,704	1.18E-02	0.31	0.03	4.37E-03	4.24E-03	9.36E-03	1.04E-03	15.24	9.43E-05	7.31E-04	15.46
-Main Engines	2			2	3,861	Diesel			1	6	0	190	24	4,560	41%	41%			7.86E-03	0.15	0.08	9.73E-03	9.44E-03	1.03E-04	8.35E-04	10.85	1.41E-03	3.14E-04	10.98
Walk-to-Work Vessel		1	354 x 52 x 31 (18)																									
-Main Generators	4			2	1,609	Diesel	10,000	3.18	1	6	0	222	24	5,328	35%	35%	786	698,113	5.50E-03	0.11	0.05	6.81E-03	6.60E-03	7.19E-05	5.84E-04	7.58	9.89E-04	2.20E-04	7.67
-Aux. Generator	1			1	1,072	Diesel			1	6	0	222	24	5,328	35%	35%			4.95E-04	0.02	9.16E-03	4.73E-04	4.58E-04	1.20E-05	4.96E-05	1.26	1.65E-04	3.66E-05	1.28
-Emergency Generator	1			1	201	Diesel			0	0	0	0	0	0	35%	35%			0	0	0	0	0	0	0	0	0	0	0
Trenching Support Vessel 1		1	426 x 72 x 36 (21)																									
-Main Generators	4			2	3,740	Diesel	15,000	3.18	1	6	0	285	24	6,840	26%	26%	1,179	1,344,340	9.62E-03	0.19	0.10	1.19E-02	1.16E-02	1.26E-04	1.02E-03	13.27	1.73E-03	3.85E-04	13.43
-Emergency Generator	1			1	550	Diesel			0	0	0	0	0	0	26%	26%			0	0	0	0	0	0	0	0	0	0	0
Trenching Support Vessel 2		1	426 x 72 x 36 (21)																									
-Main Generators	4			2	3,740	Diesel	15,000	3.18	1	6	0	285	24	6,840	26%	26%	1,179	1,344,340	9.62E-03	0.19	0.10	1.19E-02	1.16E-02	1.26E-04	1.02E-03	13.27	1.73E-03	3.85E-04	13.43
-Emergency Generator	1			1	550	Diesel			0	0	0	0	0	0	26%	26%			0	0	0	0	0	0	0	0	0	0	0
Pre-Lay Grapnel Run Vessel		N/A	150 x 36 x 10																									
-Main Engines	2			1	750	Diesel	6,000	3.18	5	12	0	37	24	888	95%	75%	4,717	69,811	0.02	0.69	0.35	0.02	0.02	4.62E-04	1.92E-03	48.76	6.36E-03	1.41E-03	49.34
-Aux. Generator	1			1	133	Diesel			5	12	0	37	24	888	95%	75%			1.69E-03	0.06	0.03	1.62E-03	1.57E-03	4.10E-05	1.70E-04	4.32	5.64E-04	1.25E-04	4.38
-Bow Thruster Engine	1			1	325	Diesel			0	0	0	37	24	888	0%	75%			0	0	0	0	0	0	0	0	0	0	0
-Aux. Engine	1			1	133	Diesel			0	0	0	37	24	888	0%	75%			0	0	0	0	0	0	0	0	0	0	0
Pre-Installation Survey Vessel		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	4,000	3.18	4	12	0	27	24	648	43%	43%	2,516	33,962	1.07E-02	0.39	0.20	1.02E-02	9.87E-03	2.58E-04	1.07E-03	27.22	3.55E-03	7.89E-04	27.54
-Aux. Generator	1			1	47	Diesel			4	12	0	27	24	648	43%	43%			2.14E-04	7.76E-03	3.96E-03	2.04E-04	1.98E-04	5.18E-06	2.15E-05	0.55	7.13E-05	1.58E-05	0.55
-Aux. Engine	1			1	47	Diesel			4	12	0	27	24	648	43%	43%			2.14E-04	7.76E-03	3.96E-03	2.04E-04	1.98E-04	5.18E-06	2.15E-05	0.55	7.13E-05	1.58E-05	0.55
As-Built Survey Vessel		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	4,000	3.18	4	12	0	27	24	648	43%	43%	2,516	33,962	1.07E-02	0.39	0.20	1.02E-02	9.87E-03	2.58E-04	1.07E-03	27.22	3.55E-03	7.89E-04	27.54
-Aux. Generator	1			1	47	Diesel			4	12	0	27	24	648	43%	43%			2.14E-04	7.76E-03	3.96E-03	2.04E-04	1.98E-04	5.18E-06	2.15E-05	0.55	7.13E-05	1.58E-05	0.55
-Aux. Engine	1			1	47	Diesel			4	12	0	27	24	648	43%	43%			2.14E-04	7.76E-03	3.96E-03	2.04E-04	1.98E-04	5.18E-06	2.15E-05	0.55	7.13E-05	1.58E-05	0.55
Crew Transfer Vessel 1		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	8,000	3.18	84	12	0	167	24	4,008	85%	85%	105,660	420,126	0.45	16.24	8.28	0.43	0.41	1.08E-02	0.04	1143.22	0.15	0.03	1,156.82
-Aux. Generator	1			1	47	Diesel			84	12	0	167	24	4,008	85%	85%			8.99E-03	0.33	0.17	8.59E-03	8.33E-03	2.18E-04	9.02E-04	22.96	3.00E-03	6.66E-04	23.24
-Aux. Engine	1			1	47	Diesel			84	12	0	167	24	4,008	85%	85%			8.99E-03	0.33	0.17	8.59E-03	8.33E-03	2.18E-04	9.02E-04	22.96	3.00E-03	6.66E-04	23.24
Crew Transfer Vessel 2		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	8,000	3.18	84	12	0	167	24	4,008	85%	85%	105,660	420,126	0.45	16.24	8.28	0.43	0.41	1.08E-02	0.04	1143.22	0.15	0.03	1,156.82
-Aux. Generator	1			1	47	Diesel			84	12	0	167	24	4,008	85%	85%			8.99E-03	0.33	0.17	8.59E-03	8.33E-03	2.18E-04	9.02E-04	22.96	3.00E-03	6.66E-04	23.24
-Aux. Engine	1			1	47	Diesel			84	12	0	167	24	4,008	85%	85%			8.99E-03	0.33	0.17	8.59E-03	8.33E-03	2.18E-04	9.02E-04	22.96	3.00E-03	6.66E-04	23.24
																TOTALS	226,494	6,097,484	1.02	36.30	18.39	0.98	0.95	0.03	0.10	2,549	0.33	0.07	2,580

Notes:
1. Inter-array cable installation is assumed to occur from January - April 2025, July - November 2025, and February - May 2026.
2. Non-transit construction emissions 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 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 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)
4. The number of transits for each vessel are based on the following assumptions:
   1 round trip to/from overseas port for export cable lay vessel, walk-to-work vessel, and trenching support vessels.
   Weekly round trips to/from local port for pre-lay grapnel run vessel and survey vessels.
   Every other day for the crew transfer vessels.
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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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_{10} or VOC emissions from the CMVs.
   The HAP 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
WTG 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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Non-Transit)								
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Jack-up Vessel 1 - WTG installation		3	456 x 164 x 36 (20)																								
-Main Engines	6			3	4,477	Diesel	20,000	3.18	47	12	0	660	24	15,840	21%	21%	147,799	4,150,943	37.19	981.83	81.82	13.78	13.37	29.51	3.28	48,056.04	0.30	2.31	48,750.61
-Emergency Generator	1			2	1,340	Diesel			0	0	0	0	0	0	21%	21%			0	0	0	0	0	0	0	0	0	0	0
Jack-up Vessel 2 - WTG installation		3	456 x 164 x 36 (20)																								
-Main Engines	6			3	4,477	Diesel	20,000	3.18	1	6	0	660	24	15,840	21%	21%	1,572	4,150,943	37.19	981.83	81.82	13.78	13.37	29.51	3.28	48,056.04	0.30	2.31	48,750.61
-Emergency Generator	1			2	1,340	Diesel			0	0	0	0	0	0	21%	21%			0	0	0	0	0	0	0	0	0	0	0
WTG Transport Tug 1		N/A	146 x 46 x 25 (21)																								
-Main Engines	2			2	5,440	Diesel	8,000	3.18	220	12	0	660	24	15,840	18%	18%	276,730	1,660,377	12.81	251.02	128.07	15.86	15.38	0.17	1.36	17,674.01	2.31	0.51	17,884.30
-Harbor Generator	1			1	456	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
WTG Transport Tug 2		N/A	146 x 46 x 25 (21)																								
-Main Engines	2			2	5,440	Diesel	8,000	3.18	220	12	0	660	24	15,840	18%	18%	276,730	1,660,377	12.81	251.02	128.07	15.86	15.38	0.17	1.36	17,674.01	2.31	0.51	17,884.30
-Harbor Generator	1			1	456	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
WTG Transport Tug 3		N/A	146 x 46 x 25 (21)																								
-Main Engines	2			2	5,440	Diesel	8,000	3.18	220	12	0	660	24	15,840	18%	18%	276,730	1,660,377	12.81	251.02	128.07	15.86	15.38	0.17	1.36	17,674.01	2.31	0.51	17,884.30
-Harbor Generator	1			1	456	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
WTG Transport Barge 1		N/A	400 x 105 x 20 (20)	N/A	N/A	N/A	0	N/A	220	12	0	660	24															
WTG Transport Barge 2		N/A	400 x 105 x 20 (20)	N/A	N/A	N/A	0	N/A	220	12	0	660	24															
Crew Transfer Vessel		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	8,000	3.18	660	12	0	660	12	7,920	85%	171%	830,189	1,660,377	7.03	255.15	130.18	6.72	6.52	0.17	0.71	17,964.90	2.34	0.52	18,178.66
-Aux. Generator	1			1	47	Diesel			660	12	0	660	12	7,920	85%	171%			0.14	5.12	2.61	0.13	0.13	3.42E-03	1.42E-02	360.83	0.05	1.05E-02	365.13
-Aux. Engine	1			1	47	Diesel			660	12	0	660	12	7,920	85%	171%			0.14	5.12	2.61	0.13	0.13	3.42E-03	1.42E-02	360.83	0.05	1.05E-02	365.13
Walk-to-Work Vessel 1 - Commissioning		1	354 x 52 x 31 (18)																								
-Main Generators	4			2	1,609	Diesel	10,000	3.18	1	6	0	660	24	15,840	35%	35%	786	2,075,472	14.51	284.36	145.08	17.97	17.43	0.19	1.54	20,021.32	2.61	0.58	20,259.55
-Aux. Generator	1			1	1,072	Diesel			1	6	0	660	24	15,840	35%	35%			1.31	47.39	24.18	1.25	1.21	0.03	0.13	3,336.89	0.44	0.10	3,376.59
-Emergency Generator	1			1	201	Diesel			0	0	0	0	0	0	35%	35%			0	0	0	0	0	0	0	0	0	0	0
Walk-to-Work Vessel 2 - Commissioning		1	354 x 52 x 31 (18)																								
-Main Generators	4			2	1,609	Diesel	10,000	3.18	1	6	0	660	24	15,840	35%	35%	786	2,075,472	14.51	284.36	145.08	17.97	17.43	0.19	1.54	20,021.32	2.61	0.58	20,259.55
-Aux. Generator	1			1	1,072	Diesel			1	6	0	660	24	15,840	35%	35%			1.31	47.39	24.18	1.25	1.21	0.03	0.13	3,336.89	0.44	0.10	3,376.59
-Emergency Generator	1			1	201	Diesel			0	0	0	0	0	0	35%	35%			0	0	0	0	0	0	0	0	0	0	0
																TOTALS	1,811,321	19,094,340	151.74	3,645.64	1,021.79	120.56	116.95	60.15	14.73	214,537.08	16.04	8.04	217,335.31

Notes:

1. WTG installation is assumed to occur from June 2025 through May 2027.
2. Non-transit construction emissions 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 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 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)
4. The number of transits for each vessel are based on the following assumptions:
   Every two weeks to/from local port for one of two jack-up vessels.
   1 round trip to/from overseas port for one of two jack-up vessels, and for commissioning vessels.
   Every 3 days to/from local port for tugs and barges.
   Daily trips for crew transfer 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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
WTG Installation Emissions

																		Total Emissions (Transit)										
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**	**Assumed fuel rate (kg per vessel per day)**	**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 Hours (hrs)**	**Transit Average load (%)**	**Non-Transit Average load (%)**	**Transit Fuel Usage Gallons (per vessel)**	**Non-Transit Fuel Usage Gallons (per vessel)**	**VOC tons**	**NO_x tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Jack-up Vessel 1 - WTG installation		3	456 x 164 x 36 (20)																									
-Main Engines	6			3	4,477	Diesel	20,000	3.18	47	12	0	660	24	15,840	21%	21%	147,799	4,150,943	1.32	34.96	2.91	0.49	0.48	1.05	0.12	1711.09	1.06E-02	0.08	1,735.82
-Emergency Generator	1			2	1,340	Diesel			0	0	0	0	0	0	21%	21%			0	0	0	0	0	0	0	0	0	0	0
Jack-up Vessel 2 - WTG installation		3	456 x 164 x 36 (20)																									
-Main Engines	6			3	4,477	Diesel	20,000	3.18	1	6	0	660	24	15,840	21%	21%	1,572	4,150,943	1.41E-02	0.37	0.03	5.22E-03	5.06E-03	1.12E-02	1.24E-03	18.20	1.13E-04	8.73E-04	18.47
-Emergency Generator	1			2	1,340	Diesel			0	0	0	0	0	0	21%	21%			0	0	0	0	0	0	0	0	0	0	0
WTG Transport Tug 1		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	220	12	0	660	24	15,840	18%	18%	276,730	1,660,377	2.13	41.84	21.35	2.64	2.56	0.03	0.23	2,945.67	0.38	0.09	2,980.72
-Harbor Generator	1			1	456	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
WTG Transport Tug 2		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	220	12	0	660	24	15,840	18%	18%	276,730	1,660,377	2.13	41.84	21.35	2.64	2.56	0.03	0.23	2,945.67	0.38	0.09	2,980.72
-Harbor Generator	1			1	456	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
WTG Transport Tug 3		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	8,000	3.18	220	12	0	660	24	15,840	18%	18%	276,730	1,660,377	2.13	41.84	21.35	2.64	2.56	0.03	0.23	2,945.67	0.38	0.09	2,980.72
-Harbor Generator	1			1	456	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			220	12	0	660	24	15,840	0%	0%			0	0	0	0	0	0	0	0	0	0	0
WTG Transport Barge 1		N/A	400 x 105 x 20 (20)	N/A	N/A	N/A	0	N/A	220	12	0	660	24																
WTG Transport Barge 2		N/A	400 x 105 x 20 (20)	N/A	N/A	N/A	0	N/A	220	12	0	660	24																
Crew Transfer Vessel		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	8,000	3.18	660	12	0	660	12	7,920	85%	171%	830,189	1,660,377	3.51	127.58	65.09	3.36	3.26	0.09	0.35	8,982.45	1.17	0.26	9,089.33
-Aux. Generator	1			1	47	Diesel			660	12	0	660	12	7,920	85%	171%			0.07	2.56	1.31	0.07	0.07	1.71E-03	7.09E-03	180.42	0.02	5.23E-03	182.56
-Aux. Engine	1			1	47	Diesel			660	12	0	660	12	7,920	85%	171%			0.07	2.56	1.31	0.07	0.07	1.71E-03	7.09E-03	180.42	0.02	5.23E-03	182.56
Walk-to-Work Vessel 1 - Commissioning		1	354 x 52 x 31 (18)																									
-Main Generators	4			2	1,609	Diesel	10,000	3.18	1	6	0	660	24	15,840	35%	35%	786	2,075,472	5.50E-03	0.11	0.05	6.81E-03	6.60E-03	7.19E-05	5.84E-04	7.58	9.89E-04	2.20E-04	7.67
-Aux. Generator	1			1	1,072	Diesel			1	6	0	660	24	15,840	35%	35%			4.95E-04	0.02	9.16E-03	4.73E-04	4.58E-04	1.20E-05	4.96E-05	1.26	1.65E-04	3.66E-05	1.28
-Emergency Generator	1			1	201	Diesel			0	0	0	0	0	0	35%	35%			0	0	0	0	0	0	0	0	0	0	0
Walk-to-Work Vessel 2 - Commissioning		1	354 x 52 x 31 (18)																									
-Main Generators	4			2	1,609	Diesel	10,000	3.18	1	6	0	660	24	15,840	35%	35%	786	2,075,472	5.50E-03	0.11	0.05	6.81E-03	6.60E-03	7.19E-05	5.84E-04	7.58	9.89E-04	2.20E-04	7.67
-Aux. Generator	1			1	1,072	Diesel			1	6	0	660	24	15,840	35%	35%			4.95E-04	0.02	9.16E-03	4.73E-04	4.58E-04	1.20E-05	4.96E-05	1.26	1.65E-04	3.66E-05	1.28
-Emergency Generator	1			1	201	Diesel			0	0	0	0	0	0	35%	35%			0	0	0	0	0	0	0	0	0	0	0
																TOTALS	**1,811,321**	**19,094,340**	**11.41**	**293.80**	**134.81**	**11.93**	**11.58**	**1.23**	**1.17**	**19,927.27**	**2.38**	**0.61**	**20,168.80**

Notes:

1. WTG installation is assumed to occur from June 2025 through May 2027.
2. Non-transit construction emissions 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 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 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)
4. The number of transits for each vessel are based on the following assumptions:
   Every two weeks to/from local port for one of two jack-up vessels.
   1 round trip to/from overseas port for one of two jack-up vessels, and for commissioning vessels.
   Every 3 days to/from local port for tugs and barges.
   Daily trips for crew transfer 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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
7. HAP 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 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)
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project.
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Auxiliary Vessels

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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Non-Transit)								
																			VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Helicopter - Twin-Engine Heavy		N/A																									
-Main Engines	2			164	1,400	Jet fuel	N/A	N/A	624	0.75	0	0	0	0	100%	0%	147,298	0	0	0	0	0	0	0	0	0	0	0
Sandwave Dredging Vessel		N/A	480 x 92 x 36 (30)																								
-Tugboat Main Engines	2			3	7,831	Diesel	25,000	3.18	98	12	0	98	12	1,176	46%	56%	385,220	770,440	4.21	111.22	9.27	1.56	1.51	3.34	0.37	5,443.73	0.03	0.26	5,522.41
-Tugboat Harbor Generator	1			1	979	Diesel			0	0	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Tugboat Emergency Generator	1			1	737	Diesel			0	0	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Dredger Pump Engines	2			3	5,000	Diesel			0	0	0	98	12	1,176	0%	56%			2.69	71.01	5.92	1.00	0.97	2.13	0.24	3,475.76	0.02	0.17	3,525.99
-Dredger Harbor Generator	1			2	1,220	Diesel			0	0	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Boulder Picking Vessel 1		N/A	146 x 46 x 25 (21)																								
-Main Engines	2			2	5,440	Diesel	10,000	3.18	14	12	0	98	24	2,352	23%	23%	22,013	308,176	2.38	46.59	23.77	2.94	2.86	0.03	0.25	3,280.40	0.43	0.10	3,319.43
-Harbor Generator	1			1	456	Diesel			14	12	0	98	24	2,352	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			14	12	0	98	24	2,352	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Boulder Picking Vessel 2		N/A	146 x 46 x 25 (21)																								
-Main Engines	2			2	5,440	Diesel	10,000	3.18	14	12	0	98	24	2,352	23%	23%	22,013	308,176	2.38	46.59	23.77	2.94	2.86	0.03	0.25	3,280.40	0.43	0.10	3,319.43
-Harbor Generator	1			1	456	Diesel			14	12	0	98	24	2,352	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			14	12	0	98	24	2,352	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Boulder Ploughing Vessel		N/A	146 x 46 x 25 (21)																								
-Main Engines	2			2	5,440	Diesel	10,000	3.18	19	12	0	131	24	3,144	23%	23%	29,874	411,950	3.18	62.28	31.78	3.94	3.82	0.04	0.34	4,385.03	0.57	0.13	4,437.20
-Harbor Generator	1			1	456	Diesel			19	12	0	131	24	3,144	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			19	12	0	131	24	3,144	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Crossing Protection Vessel		N/A	190 x 36 x 11 (11)																								
-Main Engines	2			2	1920	Diesel	8,000	3.18	27	12	0	189	24	4,536	48%	48%	33,962	475,472	3.47	67.94	34.66	4.29	4.16	0.05	0.37	4,783.42	0.62	0.14	4,840.33
-Main Generators	2			1	228	Diesel			27	12	0	189	24	4,536	48%	48%			0.22	8.06	4.11	0.21	0.21	5.38E-03	0.02	567.74	0.07	0.02	574.49
Noise monitoring vessel 1		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	5,000	3.18	1428	12	0	1428	24	34,272	53%	53%	1,122,642	2,245,283	9.51	345.04	176.04	9.08	8.81	0.23	0.95	24,293.44	3.17	0.70	24,582.50
-Aux. Generator	1			1	47	Diesel			1428	12	0	1428	24	34,272	53%	53%			0.19	6.93	3.54	0.18	0.18	4.62E-03	0.02	487.95	0.06	1.41E-02	493.75
-Aux. Engine	1			1	47	Diesel			1428	12	0	1428	24	34,272	53%	53%			0.19	6.93	3.54	0.18	0.18	4.62E-03	0.02	487.95	0.06	1.41E-02	493.75
Noise monitoring vessel 2		N/A	114 x 24 x 7																								
-Main Engines	4			1	585	Diesel	5,000	3.18	1428	12	0	1428	24	34,272	53%	53%	1,122,642	2,245,283	9.51	345.04	176.04	9.08	8.81	0.23	0.95	24,293.44	3.17	0.70	24,582.50
-Aux. Generator	1			1	47	Diesel			1428	12	0	1428	24	34,272	53%	53%			0.19	6.93	3.54	0.18	0.18	4.62E-03	0.02	487.95	0.06	1.41E-02	493.75
-Aux. Engine	1			1	47	Diesel			1428	12	0	1428	24	34,272	53%	53%			0.19	6.93	3.54	0.18	0.18	4.62E-03	0.02	487.95	0.06	1.41E-02	493.75
Safety Vessel		N/A	65 x 17 x 5																								
-Main Engines	2			1	660	Diesel	5,000	3.18	111	12	0	1,557	24	37,368	95%	95%	87,264	2,448,113	10.36	376.04	191.86	9.90	9.60	0.25	1.04	26,476.57	3.45	0.77	26,791.60
-Main Generators	2			1	27	Diesel			111	12	0	1,557	24	37,368	95%	95%			0.42	15.28	7.79	0.40	0.39	1.02E-02	0.04	1,075.50	0.14	0.03	1,088.29
																	TOTALS		**49.08**	**1,522.81**	**699.16**	**46.08**	**44.70**	**6.37**	**4.91**	**103,307**	**12.37**	**3.16**	**104,559**

Notes:
1. Auxiliary vessels are assumed to operate from September 2023 through August 2027.
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 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 nm; OCS radius: 30 nm)
4. The number of transits for each vessel are based on the following assumptions:
   Daily trips to/from local port for the sandwave dredging vessel and the noise monitoring vessels.
   Weekly trips to/from local port for the boulder picking and boulder ploughing vessels.
   Up to 27 trips to/from local port for the crossing protection vessel.
   Bi-weekly trips to/from local port for the safety vessel.
5. Helicopter transit emissions assume 624 total round trips (four trips per week 2024-2026), with a duration of 45 minutes per round trip, based on travel from Virginia Beach Airport (41 mi one-way distance, 9 mi over Virginia Beach/VA state waters, and 32 mi inside OCS radius).
6. 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.
7. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
8. HAP 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_{10} or VOC emissions from the CMVs.
   The HAP 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. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Auxiliary Vessels

																		Total Emissions (Transit)									
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**	**Assumed fuel rate (kg per vessel per day)**	**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 Hours (hrs)**	**Transit Average load (%)**	**Non-Transit Average load (%)**	**Transit Fuel Usage Gallons (per vessel)**	**Non-Transit Fuel Usage Gallons (per vessel)**	**VOC tons**	**NO_x tons**	**CO tons**	**PM_{10} tons**	**$PM_{2.5}$ tons**	**SO_2 tons**	**HAPs tons**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Helicopter - Twin-Engine Heavy		N/A																										
-Main Engines	2			164	1,400	Jet fuel	N/A	N/A	624	0.75	0	0	0	0	100%	0%	147,298	0	0.62	8.11	0.19	0.19	0.19	0.49	0.02	1,553.87	0.04	0.05	1,570.32
Sandwave Dredging Vessel		N/A	480 x 92 x 36 (30)																									
-Tugboat Main Engines	2			3	7,831	Diesel	25,000	3.18	98	12	0	98	12	1,176	46%	56%	385,220	770,440	3.45	91.12	7.59	1.28	1.24	2.74	0.30	4,459.75	0.03	0.21	4,524.20
-Tugboat Harbor Generator	1			1	979	Diesel			0	0	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Tugboat Emergency Generator	1			1	737	Diesel			0	0	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Dredger Pump Engines	2			3	5,000	Diesel			0	0	0	98	12	1,176	0%	56%			0	0	0	0	0	0	0	0	0	0	0
-Dredger Harbor Generator	1			2	1,220	Diesel			0	0	0	0	0	0	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Boulder Picking Vessel 1		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	10,000	3.18	14	12	0	98	24	2,352	23%	23%	22,013	308,176	0.17	3.33	1.70	0.21	0.20	2.22E-03	0.02	234.31	0.03	6.79E-03	237.10
-Harbor Generator	1			1	456	Diesel			14	12	0	98	24	2,352	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			14	12	0	98	24	2,352	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Boulder Picking Vessel 2		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	10,000	3.18	14	12	0	98	24	2,352	23%	23%	22,013	308,176	0.17	3.33	1.70	0.21	0.20	2.22E-03	0.02	234.31	0.03	6.79E-03	237.10
-Harbor Generator	1			1	456	Diesel			14	12	0	98	24	2,352	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			14	12	0	98	24	2,352	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Boulder Ploughing Vessel		N/A	146 x 46 x 25 (21)																									
-Main Engines	2			2	5,440	Diesel	10,000	3.18	19	12	0	131	24	3,144	23%	23%	29,874	411,950	0.23	4.52	2.30	0.29	0.28	3.01E-03	0.02	318.00	0.04	9.22E-03	321.78
-Harbor Generator	1			1	456	Diesel			19	12	0	131	24	3,144	0%	0%			0	0	0	0	0	0	0	0	0	0	0
-Emergency Generator	1			1	168	Diesel			19	12	0	131	24	3,144	0%	0%			0	0	0	0	0	0	0	0	0	0	0
Crossing Protection Vessel		N/A	190 x 36 x 11 (11)																									
-Main Engines	2			2	1920	Diesel	8,000	3.18	27	12	0	189	24	4,536	48%	48%	33,962	475,472	0.25	4.85	2.48	0.31	0.30	3.24E-03	0.03	341.67	0.04	9.90E-03	345.74
-Main Generators	2			1	228	Diesel			27	12	0	189	24	4,536	48%	48%			0.02	0.58	0.29	0.02	1.47E-02	3.84E-04	1.59E-03	40.55	5.29E-03	1.18E-03	41.04
Noise monitoring vessel 1		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	5,000	3.18	1428	12	0	1428	24	34,272	53%	53%	1,122,642	2,245,283	4.75	172.52	88.02	4.54	4.41	0.12	0.48	12,146.72	1.58	0.35	12,291.25
-Aux. Generator	1			1	47	Diesel			1428	12	0	1428	24	34,272	53%	53%			0.10	3.47	1.77	0.09	0.09	2.31E-03	9.58E-03	243.97	0.03	7.07E-03	246.88
-Aux. Engine	1			1	47	Diesel			1428	12	0	1428	24	34,272	53%	53%			0.10	3.47	1.77	0.09	0.09	2.31E-03	9.58E-03	243.97	0.03	7.07E-03	246.88
Noise monitoring vessel 2		N/A	114 x 24 x 7																									
-Main Engines	4			1	585	Diesel	5,000	3.18	1428	12	0	1428	24	34,272	53%	53%	1,122,642	2,245,283	4.75	172.52	88.02	4.54	4.41	0.12	0.48	12,146.72	1.58	0.35	12,291.25
-Aux. Generator	1			1	47	Diesel			1428	12	0	1428	24	34,272	53%	53%			0.10	3.47	1.77	0.09	0.09	2.31E-03	9.58E-03	243.97	0.03	7.07E-03	246.88
-Aux. Engine	1			1	47	Diesel			1428	12	0	1428	24	34,272	53%	53%			0.10	3.47	1.77	0.09	0.09	2.31E-03	9.58E-03	243.97	0.03	7.07E-03	246.88
Safety Vessel		N/A	65 x 17 x 5																									
-Main Engines	2			1	660	Diesel	5,000	3.18	111	12	0	1,557	24	37,368	95%	95%	87,264	2,448,113	0.37	13.40	6.84	0.35	0.34	8.94E-03	0.04	943.77	0.12	0.03	955.00
-Main Generators	2			1	27	Diesel			111	12	0	1,557	24	37,368	95%	95%			0.02	0.54	0.28	1.43E-02	1.39E-02	3.63E-04	1.51E-03	38.34	5.00E-03	1.11E-03	38.79
																	TOTALS		**15.18**	**488.67**	**206.48**	**12.31**	**11.95**	**3.49**	**1.44**	**33,434**	**3.65**	**1.06**	**33,841**

Notes:
1. Auxiliary vessels are assumed to operate from September 2023 through August 2027.
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 10 knots for all vessel types, and the following one-way travel distances:
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 nm; OCS radius: 30 nm)
4. The number of transits for each vessel are based on the following assumptions:
   Daily trips to/from local port for the sandwave dredging vessel and the noise monitoring vessels.
   Weekly trips to/from local port for the boulder picking and boulder ploughing vessels.
   Up to 27 trips to/from local port for the crossing protection vessel.
   Bi-weekly trips to/from local port for the safety vessel.
5. Helicopter transit emissions assume 624 total round trips (four trips per week 2024-2026), with a duration of 45 minutes per round trip, based on travel from Virginia Beach Airport (41 mi one-way distance, 9 mi over Virginia Beach/VA state waters, and 32 mi inside OCS radius).
6. 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.
7. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009.
8. HAP 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_{10} or VOC emissions from the CMVs.
   The HAP 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. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4 and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Onshore Substation, Switching Station, Onshore Cables, and Cable Landfall - 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**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Land-based Nonroad Equip.																			
ONSHORE SUBSTATION																			
Large Bulldozer	2270002069	800	diesel	115	8	59%	30	125,030	0.19	6.95	0.69	0.14	0.14	9.84E-03	0.05	1407.14	1.17E-02	0.04	1418.11
All-Terrain Forklift	2270002057	150	diesel	113	8	59%	45	35,170	0.03	0.41	0.15	0.03	0.03	2.71E-03	8.02E-03	395.82	2.51E-03	1.01E-02	398.89
Front End Loader	2270002060	200	diesel	114	8	59%	22	22,928	1.29E-02	0.15	0.05	1.17E-02	1.13E-02	1.75E-03	3.10E-03	258.04	8.92E-04	6.57E-03	260.02
Medium Crane	2270002045	400	diesel	112	8	43%	30	45,072	0.06	1.23	0.30	0.05	0.05	3.70E-03	0.02	507.26	3.99E-03	1.29E-02	511.21
Medium Aerial Lift	2270003010	20	diesel	116	8	21%	30	1,437	0.02	0.11	0.09	1.18E-02	1.14E-02	1.49E-04	5.53E-03	16.17	7.82E-04	4.12E-04	16.32
Medium Excavator	2270002036	200	diesel	111	8	59%	37	38,563	1.16E-02	0.16	0.04	1.04E-02	1.01E-02	2.88E-03	2.80E-03	434.00	7.49E-04	1.11E-02	437.32
Piling Rig	2270002033	200	diesel	110	8	43%	7	5,251	0.04	0.47	0.10	0.02	0.02	5.25E-04	8.77E-03	59.10	1.90E-03	1.50E-03	59.59
Generator	2270006005	150	diesel	117	8	43%	45	25,335	0.10	1.26	0.36	0.08	0.08	2.20E-03	0.03	285.13	4.09E-03	7.26E-03	287.40
SWITCHING STATION																			
Large Bulldozer	2270002069	800	diesel	105	8	59%	32	133,366	0.21	7.42	0.74	0.15	0.15	1.05E-02	0.05	1500.95	1.25E-02	0.04	1512.65
All-Terrain Forklift	2270002057	150	diesel	103	8	59%	48	37,515	0.04	0.43	0.15	0.03	0.03	2.89E-03	8.56E-03	422.21	2.68E-03	1.08E-02	425.48
Front End Loader	2270002060	200	diesel	104	8	59%	24	25,012	1.41E-02	0.17	0.06	1.27E-02	1.23E-02	1.90E-03	3.39E-03	281.50	9.73E-04	7.17E-03	283.66
Medium Crane	2270002045	400	diesel	102	8	43%	32	48,077	0.07	1.31	0.32	0.05	0.05	3.95E-03	0.02	541.08	4.25E-03	1.38E-02	545.29
Medium Aerial Lift	2270003010	20	diesel	106	8	21%	32	1,533	0.02	0.12	0.10	1.26E-02	1.22E-02	1.59E-04	5.90E-03	17.25	8.34E-04	4.39E-04	17.40
Medium Excavator	2270002036	200	diesel	101	8	59%	43	44,816	1.35E-02	0.18	0.05	1.20E-02	1.17E-02	3.35E-03	3.26E-03	504.38	8.71E-04	1.28E-02	508.23
Piling Rig	2270002033	200	diesel	100	8	43%	8	6,001	0.04	0.53	0.12	0.03	0.02	6.00E-04	1.00E-02	67.54	2.17E-03	1.72E-03	68.11
Generator	2270006005	150	diesel	107	8	43%	48	27,024	0.11	1.34	0.39	0.08	0.08	2.35E-03	0.03	304.14	4.36E-03	7.75E-03	306.56
CABLE LANDFALL																			
Large Bulldozer	2270002069	800	diesel	105	8	59%	5	20,838	0.03	1.16	0.12	0.02	0.02	1.64E-03	7.74E-03	234.52	1.95E-03	5.97E-03	236.35
All-Terrain Forklift	2270002057	150	diesel	103	8	59%	5	3,908	3.70E-03	0.05	0.02	3.55E-03	3.44E-03	3.01E-04	8.91E-04	43.98	2.79E-04	1.12E-03	44.32
Front End Loader	2270002060	200	diesel	104	8	59%	5	5,211	2.93E-03	0.03	1.19E-02	2.65E-03	2.57E-03	3.97E-04	7.05E-04	58.65	2.03E-04	1.49E-03	59.10
Medium Crane	2270002045	400	diesel	102	8	43%	5	7,512	1.06E-02	0.21	0.05	8.02E-03	7.78E-03	6.16E-04	2.55E-03	84.54	6.65E-04	2.15E-03	85.20
Medium Aerial Lift	2270003010	20	diesel	106	8	21%	5	240	3.83E-03	0.02	1.50E-02	1.96E-03	1.90E-03	2.48E-05	9.22E-04	2.70	1.30E-04	6.86E-05	2.72
Medium Excavator	2270002036	200	diesel	101	8	59%	5	5,211	1.57E-03	0.02	5.71E-03	1.40E-03	1.36E-03	3.90E-04	3.79E-04	58.65	1.01E-04	1.49E-03	59.10
Piling Rig	2270002033	200	diesel	100	8	43%	5	3,751	0.03	0.33	0.07	0.02	0.02	3.75E-04	6.26E-03	42.21	1.36E-03	1.07E-03	42.57
Generator	2270006005	150	diesel	107	8	43%	5	2,815	1.16E-02	0.14	0.04	8.85E-03	8.58E-03	2.44E-04	2.79E-03	31.68	4.54E-04	8.07E-04	31.93
ONSHORE EXPORT CABLE																			
Onshore Cable Route HDD Drill Rig	2270002033	200	diesel	100	8	43%	750	562,613	3.91	49.84	10.89	2.37	2.30	0.06	0.94	6331.87	0.20	0.16	6385.01
Onshore Cable Route Compressor	2270006015	150	diesel	108	8	43%	750	422,588	0.45	7.93	1.88	0.47	0.46	0.03	0.11	4755.98	0.04	0.12	4792.99
Onshore Cable Route Excavator	2270002036	200	diesel	101	8	59%	750	781,682	0.24	3.19	0.86	0.21	0.20	0.06	0.06	8797.37	0.02	0.22	8864.51
Onshore Cable Route Tractor	2270002075	450	diesel	105.1	8	59%	750	1,758,534	1.54	27.63	10.05	1.54	1.49	0.14	0.37	19791.26	0.10	0.50	19944.06
INTERCONNECTION CABLE																			
Large Bulldozer	2270002069	800	diesel	105	8	59%	19	79,186	0.12	4.40	0.44	0.09	0.09	6.23E-03	0.03	891.19	7.41E-03	0.02	898.14
All-Terrain Forklift	2270002057	150	diesel	103	8	59%	19	14,850	1.41E-02	0.17	0.06	1.35E-02	1.31E-02	1.15E-03	3.39E-03	167.12	1.06E-03	4.26E-03	168.42
Front End Loader	2270002060	200	diesel	104	8	59%	19	19,801	1.11E-02	0.13	0.05	1.01E-02	9.77E-03	1.51E-03	2.68E-03	222.85	7.70E-04	5.67E-03	224.56
Medium Crane	2270002045	400	diesel	102	8	43%	19	28,546	0.04	0.78	0.19	0.03	0.03	2.34E-03	9.68E-03	321.26	2.53E-03	8.18E-03	323.77
Medium Aerial Lift	2270003010	20	diesel	106	8	21%	19	910	1.46E-02	0.07	0.06	7.45E-03	7.23E-03	9.42E-05	3.50E-03	10.24	4.95E-04	2.61E-04	10.33
Medium Excavator	2270002036	200	diesel	101	8	59%	19	19,803	5.97E-03	0.08	0.02	5.32E-03	5.16E-03	1.48E-03	1.44E-03	222.87	3.85E-04	5.68E-03	224.57
Piling Rig	2270002033	200	diesel	100	8	43%	19	14,253	0.10	1.26	0.28	0.06	0.06	1.42E-03	0.02	160.41	5.15E-03	4.08E-03	161.75
Generator	2270006005	150	diesel	107	8	43%	19	10,697	0.04	0.53	0.15	0.03	0.03	9.29E-04	1.06E-02	120.39	1.73E-03	3.07E-03	121.35
Onroad Vehicles																			
Semi-Truck		-	diesel	131	-	-	24	3,028	9.66E-03	0.06	0.04	2.19E-03	2.01E-03	2.86E-04	1.25E-03	34.08	4.26E-03	1.26E-04	34.22
Work Truck		-	diesel	133	-	-	36	2,559	0.03	0.07	0.21	2.87E-03	2.64E-03	2.45E-04	2.80E-03	28.80	5.92E-03	1.33E-04	28.99
Refuse Truck		-	diesel	132	-	-	24	4,242	9.43E-03	0.13	0.08	5.07E-03	4.67E-03	4.06E-04	9.64E-04	47.74	2.58E-03	7.24E-05	47.83
Dump Truck		-	diesel	131	-	-	120	15,139	0.05	0.28	0.21	1.09E-02	1.01E-02	1.43E-03	6.26E-03	170.39	0.02	6.32E-04	171.11
Concrete Truck		-	diesel	131	-	-	24	3,028	9.66E-03	0.06	0.04	2.19E-03	2.01E-03	2.86E-04	1.25E-03	34.08	4.26E-03	1.26E-04	34.22
Worker Commute																			
Light Commercial Truck		-	diesel	134	-	-	120	6,576	0.04	0.11	0.31	3.26E-03	3.00E-03	6.22E-04	4.80E-03	74.01	0.02	3.35E-04	74.51
Passenger Truck		-	gasoline	135	-	-	72	2,928	0.03	0.03	0.38	7.09E-04	6.27E-04	5.77E-04	2.83E-03	28.34	1.22E-03	9.40E-04	28.65
							Total	**4,422,579**	**7.73**	**120.94**	**30.23**	**5.68**	**5.50**	**0.36**	**1.84**	**49,768.91**	**0.50**	**1.26**	**50,156.51**

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 2024.
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 2024.
8. Footprint for onshore substation is assumed to be 21.3 acres.
9. Footprint for onshore switching station is assumed to be 26.3 acres (including temporary workspace).
10. Footprint for onshore cable landing is assumed to be 2.83 acres.
11. Length of onshore export cable is assumed to be 4.9 miles.
12. Length of onshore interconnection cable is assumed to be 18.7 miles.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Onshore Pre-Assembly and T+I 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**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Land-based Nonroad Equip.																			
ONSHORE PRE-ASSEMBLY																			
1350t Crane x1	2270002045	1000	diesel	112	8	43%	24	90,144	0.13	2.46	0.60	0.10	0.09	7.40E-03	0.03	1014.52	7.98E-03	0.03	1022.42
300t Crane x1	2270002045	500	diesel	112	8	43%	24	45,072	0.06	1.23	0.30	0.05	0.05	3.70E-03	0.02	507.26	3.99E-03	1.29E-02	511.21
150t Crane x1	2270002045	250	diesel	112	8	43%	24	22,536	0.03	0.62	0.15	0.02	0.02	1.85E-03	7.65E-03	253.63	1.99E-03	6.46E-03	255.60
SPMT Nacelle x2	2270002075	470	diesel	115.1	8	59%	48	117,548	0.10	1.85	0.67	0.10	0.10	9.27E-03	0.02	1322.94	6.97E-03	0.03	1333.15
50T Mobile Crane x1	2270002045	200	diesel	112	8	43%	24	18,029	0.03	0.49	0.12	0.02	0.02	1.48E-03	6.12E-03	202.90	1.60E-03	5.17E-03	204.48
Forklift 16t x2	2270002057	150	diesel	113	8	59%	48	37,515	0.04	0.43	0.15	0.03	0.03	2.89E-03	8.56E-03	422.21	2.68E-03	1.08E-02	425.48
Forklift 3.5t x3	2270002057	75	diesel	113	8	59%	72	28,136	0.03	0.32	0.12	0.03	0.02	2.17E-03	6.42E-03	316.66	2.01E-03	8.06E-03	319.11
Blade mover x2	2270002075	470	diesel	115.1	8	59%	48	117,548	0.10	1.85	0.67	0.10	0.10	9.27E-03	0.02	1322.94	6.97E-03	0.03	1333.15
Tower mover x2	2270002075	470	diesel	115.1	8	59%	48	117,548	0.10	1.85	0.67	0.10	0.10	9.27E-03	0.02	1322.94	6.97E-03	0.03	1333.15
ONSHORE T&I																			
SPMT (up to 72 axles) x1	2270002069	3700	diesel	115	8	59%	29	558,990	0.86	31.08	3.09	0.63	0.61	0.04	0.21	6291.10	0.05	0.16	6340.15
Crawler crane x1	2270002045	185	diesel	112	8	43%	29	20,151	0.03	0.55	0.13	0.02	0.02	1.65E-03	6.84E-03	226.79	1.78E-03	5.78E-03	228.55
							Total	**1,173,218**	**1.51**	**42.73**	**6.68**	**1.21**	**1.17**	**0.09**	**0.36**	**13,203.88**	**0.10**	**0.34**	**13,306.46**

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. Nonroad emission factors for criteria pollutants and GHG were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2024
4. 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, 20

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	Total Emissions (Non-Transit) VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Helicopter - Twin-Engine Heavy		N/A																											
-Main Engines	2			164	1,400	Jet fuel	N/A	N/A	50	0.75	0	0	0	0	100%	0%	11,803	0	0	0	0	0	0	0	0	0	0	0	0
Service Operations Vessel		1	243 x 56 x 26 (21)																										
-Main Generators	2			2	2,466	Diesel	10,000	3.18	26	12	0	352	24	8,448	30%	30%	40,881	1,106,918	5.16	101.11	51.58	6.39	6.20	0.07	0.55	7,118.69	0.93	0.21	7,203.39
-Main Generators	2			2	1,850	Diesel			26	12	0	352	24	8,448	30%	30%			3.87	75.83	38.69	4.79	4.65	0.05	0.41	5,339.02	0.70	0.15	5,402.55
-Emergency Generator	1			1	382	Diesel			0	0	0	0	0	0	30%	30%			0	0	0	0	0	0	0	0	0	0	0
Crew Transfer Vessel 1		N/A	114 x 24 x 7																										
-Main Engines	4			1	585	Diesel	8,000	3.18	26	12	0	352	24	8,448	85%	85%	32,704	885,535	3.75	136.08	69.43	3.58	3.48	0.09	0.38	9,581.28	1.25	0.28	9,695.28
-Aux. Generator	1			1	47	Diesel			26	12	0	352	24	8,448	85%	85%			0.08	2.73	1.39	0.07	0.07	1.82E-03	7.56E-03	192.44	0.03	5.58E-03	194.73
-Aux. Engine	1			1	47	Diesel			26	12	0	352	24	8,448	85%	85%			0.08	2.73	1.39	0.07	0.07	1.82E-03	7.56E-03	192.44	0.03	5.58E-03	194.73
Crew Transfer Vessel 2		N/A	114 x 24 x 7																										
-Main Engines	4			1	585	Diesel	8,000	3.18	26	12	0	352	24	8,448	85%	85%	32,704	885,535	3.75	136.08	69.43	3.58	3.48	0.09	0.38	9,581.28	1.25	0.28	9,695.28
-Aux. Generator	1			1	47	Diesel			26	12	0	352	24	8,448	85%	85%			0.08	2.73	1.39	0.07	0.07	1.82E-03	7.56E-03	192.44	0.03	5.58E-03	194.73
-Aux. Engine	1			1	47	Diesel			26	12	0	352	24	8,448	85%	85%			0.08	2.73	1.39	0.07	0.07	1.82E-03	7.56E-03	192.44	0.03	5.58E-03	194.73
																TOTALS	118,092	2,877,987	16.83	460.03	234.71	18.63	18.07	0.31	1.74	32,390	4.22	0.94	32,775

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 10 knots for all vessel types, and the following one-way travel distances
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 nm; OCS radius: 30 nm)
3. The number of transits for each vessel are based on the following assumptions
   Monthly round trips to/from port for the service operations vessel.
   Bi-weekly round trips to/from port for crew transfer vessels.
4. Helicopter transit emissions assume 50 total round trips per year, with a duration of 45 minutes per round trip, based on travel from Virginia Beach Airport (41 mi one-way distance, 9 mi over Virginia Beach/VA state waters, and 32 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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009
7. HAP 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 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
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Offshore Operations Emissions

																	Total Emissions (Transit)										
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	Assumed fuel rate (kg per vessel per day)	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 Hours (hrs)	Transit Average load (%)	Non-Transit Average load (%)	Transit Fuel Usage Gallons (per vessel)	Non-Transit Fuel Usage Gallons (per vessel)	VOC tons	NO_x tons	CO tons	PM_{10} tons	$PM_{2.5}$ tons	SO_2 tons	HAPs tons	CO_2 tons	CH_4 tons	N_2O tons	CO_2e tons
Helicopter - Twin-Engine Heavy		N/A																											
-Main Engines	2			164	1,400	Jet fuel	N/A	N/A	50	0.75	0	0	0	0	100%	0%	11,803	0	0.05	0.65	0.02	0.02	0.02	0.04	1.30E-03	124.51	3.56E-03	4.13E-03	125.83
Service Operations Vessel		1	243 x 56 x 26 (21)																										
-Main Generators	2			2	2,466	Diesel	10,000	3.18	26	12	0	352	24	8,448	30%	30%	40,881	1,106,918	0.19	3.73	1.91	0.24	0.23	2.49E-03	0.02	262.91	0.03	7.62E-03	266.03
-Main Generators	2			2	1,850	Diesel			26	12	0	352	24	8,448	30%	30%			0.14	2.80	1.43	0.18	0.17	1.87E-03	0.02	197.18	0.03	5.72E-03	199.53
-Emergency Generator	1			1	382	Diesel			0	0	0	0	0	0	30%	30%			0	0	0	0	0	0	0	0	0	0	0
Crew Transfer Vessel 1		N/A	114 x 24 x 7																										
-Main Engines	4			1	585	Diesel	8,000	3.18	26	12	0	352	24	8,448	85%	85%	32,704	885,535	0.14	5.03	2.56	0.13	0.13	3.35E-03	1.39E-02	353.85	0.05	1.03E-02	358.06
-Aux. Generator	1			1	47	Diesel			26	12	0	352	24	8,448	85%	85%			2.78E-03	0.10	0.05	2.66E-03	2.58E-03	6.74E-05	2.79E-04	7.11	9.27E-04	2.06E-04	7.19
-Aux. Engine	1			1	47	Diesel			26	12	0	352	24	8,448	85%	85%			2.78E-03	0.10	0.05	2.66E-03	2.58E-03	6.74E-05	2.79E-04	7.11	9.27E-04	2.06E-04	7.19
Crew Transfer Vessel 2		N/A	114 x 24 x 7																										
-Main Engines	4			1	585	Diesel	8,000	3.18	26	12	0	352	24	8,448	85%	85%	32,704	885,535	0.14	5.03	2.56	0.13	0.13	3.35E-03	1.39E-02	353.85	0.05	1.03E-02	358.06
-Aux. Generator	1			1	47	Diesel			26	12	0	352	24	8,448	85%	85%			2.78E-03	0.10	0.05	2.66E-03	2.58E-03	6.74E-05	2.79E-04	7.11	9.27E-04	2.06E-04	7.19
-Aux. Engine	1			1	47	Diesel			26	12	0	352	24	8,448	85%	85%			2.78E-03	0.10	0.05	2.66E-03	2.58E-03	6.74E-05	2.79E-04	7.11	9.27E-04	2.06E-04	7.19
																TOTALS	118,092	2,877,987	0.67	17.64	8.68	0.70	0.68	0.05	0.07	1,321	0.16	0.04	1,336

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 10 knots for all vessel types, and the following one-way travel distances
   Portsmouth, VA to center of OCS lease area: 60 nm (State waters: 30 nm; OCS radius: 30 nm)
3. The number of transits for each vessel are based on the following assumptions
   Monthly round trips to/from port for the service operations vessel.
   Bi-weekly round trips to/from port for crew transfer vessels.
4. Helicopter transit emissions assume 50 total round trips per year, with a duration of 45 minutes per round trip, based on travel from Virginia Beach Airport (41 mi one-way distance, 9 mi over Virginia Beach/VA state waters, and 32 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. Emission factors for marine vessel engines are from ICF International report to the US EPA "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009
7. HAP 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 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
8. Average load factors for vessel engines were estimated based on typical daily fuel use rates provided by the project
9. CO_2e emission rates use the following carbon equivalence factors: 25 for CH_4, and 298 for N_2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Onshore 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**	**CO_2 tons**	**CH_4 tons**	**N_2O tons**	**CO_2e tons**
Land-based Nonroad Equip.																			
O&M BASE																			
Forklift 10t x1	2270002057	150	diesel	113	8	59%	12	9,379	8.88E-03	0.11	0.04	8.52E-03	8.26E-03	7.24E-04	2.14E-03	105.55	6.69E-04	2.69E-03	106.37
Forklift 4t x2	2270002057	75	diesel	113	8	59%	12	4,689	4.44E-03	0.05	0.02	4.26E-03	4.13E-03	3.62E-04	1.07E-03	52.78	3.35E-04	1.34E-03	53.18
							Total	**14,068**	**1.33E-02**	**0.16**	**0.06**	**1.28E-02**	**1.24E-02**	**1.09E-03**	**3.21E-03**	**158.33**	**1.00E-03**	**4.03E-03**	**159.55**

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.
5. Nonroad emission factors for criteria pollutants and GHG were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2024
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, 20

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
OSS Generator Emissions

Generator Engine Data

Generator Manufacturer	TBD	
Model	TBD	
Engine Type	TBD	
Rated engine output	kW	500
Rated engine output	bhp	670
Engine speed	rpm	1800
Fuel consumption at 100% load	gal/hr	33.5
Number of generators	engines	3
Annual operating hours per generator	hr/yr	500
Annual Fuel Usage per generator	gal/yr	16,756

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)	4.69

Engine Emission Factors

NOx	g/kWh	0.67
CO	g/kWh	3.5
HC (VOC)	g/kWh	0.19
PM/PM10	g/kWh	0.03
PM2.5	g/kWh	0.03
SO2	lb/MMBtu (HHV)	0.0016
HAP	lb/MMBtu (HHV)	0.0016
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)	0.74
CO	lb/hr (per engine)	3.86
VOC	lb/hr (per engine)	0.21
PM10	lb/hr (per engine)	0.03
PM2.5	lb/hr (per engine)	0.03
SO2	lb/hr (per engine)	7.28E-03
HAP	lb/hr (per engine)	7.47E-03
CO2	lb/hr (per engine)	765.0
CH4	lb/hr (per engine)	3.10E-02
N2O	lb/hr (per engine)	6.21E-03
CO2e	lb/hr (per engine)	767.6

	Short Term Emissions (lb/hr per engine)	**Annual Emissions (tons/yr all 3 engines)**
NOx	0.74	0.55
CO	3.86	2.89
VOC	0.21	0.16
PM10	0.03	0.02
PM2.5	0.03	0.02
SO2	7.28E-03	5.46E-03
HAP	7.47E-03	5.60E-03
CO2	765.0	574
CH4	0.03	0.02
N2O	6.21E-03	4.65E-03
CO2e	767.6	576

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, 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 4 final standards from Table 1 of 40 CFR 1039.101.
4. NOx+NMHC limit is 4.7 g/kWh; split into NOx and VOC based on Tier 1 limits of 9.2 g/kWh (NOx) and 1.3 g/kWh (VOC).
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. 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.
8. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Offshore Switchgear SF6 Emissions

OSS Platform Circuit Breaker SF_6 [1] Fugitive Emissions

Total SF_6 Storage Capacity [2]	lbs	39,684.0
SF_6 Leak Rate (by weight) [3]	% per year	0.5%
SF_6 Emissions	lbs/year	198.42
SF_6 Emissions	tons/year	0.0992
Annual GHG emissions (CO_2e) [4]	tons/year	2261.99

1. SF_6 = Sulfur Hexafluoride
2. OSS capacity is maximum total storage for all three OSS platforms, based on project description. WTG storage capacity is assumed value.
3. Leak rate for the SF6 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. CO_2e emission rates use the following carbon equivalence factors based on Table A-1 to Subpart A of 40 CFR Part 98—Global Warming Potentials: 22,800 for SF6.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Onshore Switching Station Generator Emissions

Generator Engine Data

Generator Manufacturer	TBD	
Model	TBD	
Engine Type	TBD	
Rated engine output	kW	260
Rated engine output	bhp	349
Engine speed	rpm	1800
Number of generators	engines	3
Annual operating hours per generator	hr/yr	500

Fuel Data and Assumptions

Fuel type	Propane	
Fuel consumption rate (assumed)	Btu/hp-hr	7,000
Heat input rate	MMBtu/hr (HHV)	2.44

Engine Emission Factors

NOx	g/kWh	2.66
CO	g/kWh	130
HC (VOC)	g/kWh	0.04
PM/PM10	lb/MMBtu (HHV)	9.50E-03
PM2.5	lb/MMBtu (HHV)	9.50E-03
SO2	lb/MMBtu (HHV)	5.88E-04
HAP	lb/MMBtu (HHV)	3.24E-02
CO2	lb/MMBtu (HHV)	138.6
CH4	lb/MMBtu (HHV)	6.61E-03
N2O	lb/MMBtu (HHV)	1.32E-03

Engine Emission Estimates

NOx	lb/hr (per engine)	1.53
CO	lb/hr (per engine)	74.51
VOC	lb/hr (per engine)	0.02
PM10	lb/hr (per engine)	2.32E-02
PM2.5	lb/hr (per engine)	2.32E-02
SO2	lb/hr (per engine)	1.43E-03
HAP	lb/hr (per engine)	7.91E-02
CO2	lb/hr (per engine)	338.1
CH4	lb/hr (per engine)	1.61E-02
N2O	lb/hr (per engine)	3.23E-03
CO2e	lb/hr (per engine)	339.5

	Short Term Emissions (lb/hr per engine)	**Annual Emissions (tons/yr all 3 engines)**
NOx	1.53	1.15
CO	74.51	55.89
VOC	0.02	0.02
PM10	0.02	0.02
PM2.5	0.02	0.02
SO2	1.43E-03	1.08E-03
HAP	0.08	0.06
CO2	338.1	254
CH4	0.02	1.21E-02
N2O	3.23E-03	2.42E-03
CO2e	339.5	255

Notes:

1. Engine power rating is based on project assumption.
2. It is assumed that the 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, and VOC are based on Tier 2 standards in 40 CFR 1048.101, paragraph (a)(2).
4. NOx+NMHC limit is 13.4 g/kWh; split into NOx and VOC based on NOx and VOC fractions in AP-42 Table 3.2-3 for four-stroke rich-burn natural gas-fired engines.
5. Emission factors for PM10, PM2.5, SO2, and HAP are from AP-42, Table 3.2-3 for four-stroke rich-burn natural gas-fired engines.
6. Emission factors used to calculate emission rates for CO2 (62.87 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.
7. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Onshore Substation Generator Emissions

Generator Engine Data		**Engine 1**	**Engine 2**	**Engine 3**
Generator Manufacturer		TBD	TBD	TBD
Model		TBD	TBD	TBD
Engine Type		TBD	TBD	TBD
Rated engine output	kW	410	310	150
Rated engine output	bhp	550	416	201
Engine speed	rpm	1800	1800	1800
Number of generators	engines	1	1	1
Annual operating hours per generator	hr/yr	500	500	500

Fuel Data and Assumptions

Fuel type		Propane	Propane	Propane
Fuel consumption rate (assumed)	Btu/hp-hr	7,000	7,000	7,000
Heat input rate	MMBtu/hr (HHV)	3.85	2.91	1.41

Engine Emission Factors

NOx	g/kWh	2.66
CO	g/kWh	130
HC (VOC)	g/kWh	0.04
PM/PM10	lb/MMBtu (HHV)	9.50E-03
PM2.5	lb/MMBtu (HHV)	9.50E-03
SO2	lb/MMBtu (HHV)	5.88E-04
HAP	lb/MMBtu (HHV)	3.24E-02
CO2	lb/MMBtu (HHV)	138.6
CH4	lb/MMBtu (HHV)	6.61E-03
N2O	lb/MMBtu (HHV)	1.32E-03

Engine Emission Estimates		**Engine 1**	**Engine 2**	**Engine 3**
NOx	lb/hr (per engine)	2.41	1.82	0.88
CO	lb/hr (per engine)	117.50	88.84	42.99
VOC	lb/hr (per engine)	0.03	0.02	1.18E-02
PM10	lb/hr (per engine)	3.65E-02	2.76E-02	1.34E-02
PM2.5	lb/hr (per engine)	3.65E-02	2.76E-02	1.34E-02
SO2	lb/hr (per engine)	2.26E-03	1.71E-03	8.28E-04
HAP	lb/hr (per engine)	1.25E-01	9.43E-02	0.05
CO2	lb/hr (per engine)	533.2	403.18	195.08
CH4	lb/hr (per engine)	2.54E-02	1.92E-02	0.01
N2O	lb/hr (per engine)	5.09E-03	3.85E-03	0.00
CO2e	lb/hr (per engine)	535.4	404.8	195.9

	Engine 1	**Engine 2**	**Engine 3**
	tons/yr	**tons/yr**	**tons/yr**
NOx	0.60	0.46	0.22
CO	29.38	22.21	10.75
VOC	0.01	6.10E-03	2.95E-03
PM10	9.14E-03	6.91E-03	3.34E-03
PM2.5	9.14E-03	6.91E-03	3.34E-03
SO2	5.66E-04	4.28E-04	2.07E-04
HAP	3.12E-02	0.02	1.14E-02
CO2	133	101	49
CH4	6.36E-03	4.81E-03	2.33E-03
N2O	1.27E-03	9.62E-04	4.65E-04
CO2e	134	101	49

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, and VOC are based on Tier 2 standards in 40 CFR 1048.101, paragraph (a)(2).
4. NOx+NMHC limit is 2.7 g/kWh; split into NOx and VOC based on NOx and VOC fractions in AP-42 Table 3.2-3 for four-stroke rich-burn natural gas-fired engines.
5. Emission factors for PM10, PM2.5, SO2, and HAP are from AP-42, Table 3.2-3 for four-stroke rich-burn natural gas-fired engines.
6. Emission factors used to calculate emission rates for CO2 (62.87 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.
7. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Onshore O+M Base Generator Emissions

Generator Engine Data

Generator Manufacturer	TBD	
Model	TBD	
Engine Type	TBD	
Rated engine output	kW	250
Rated engine output	bhp	335
Engine speed	rpm	1800
Number of generators	engines	1
Annual operating hours per generator	hr/yr	500

Fuel Data and Assumptions

Fuel type	Propane	
Fuel consumption rate (assumed)	Btu/hp-hr	7,000
Heat input rate	MMBtu/hr (HHV)	2.35

Engine Emission Factors

NOx	g/kWh	2.66
CO	g/kWh	130
HC (VOC)	g/kWh	0.04
PM/PM10	lb/MMBtu (HHV)	9.50E-03
PM2.5	lb/MMBtu (HHV)	9.50E-03
SO2	lb/MMBtu (HHV)	5.88E-04
HAP	lb/MMBtu (HHV)	3.24E-02
CO2	lb/MMBtu (HHV)	138.6
CH4	lb/MMBtu (HHV)	6.61E-03
N2O	lb/MMBtu (HHV)	1.32E-03

Engine Emission Estimates

NOx	lb/hr (per engine)	1.47
CO	lb/hr (per engine)	71.65
VOC	lb/hr (per engine)	0.02
PM10	lb/hr (per engine)	2.23E-02
PM2.5	lb/hr (per engine)	2.23E-02
SO2	lb/hr (per engine)	1.38E-03
HAP	lb/hr (per engine)	7.60E-02
CO2	lb/hr (per engine)	325.1
CH4	lb/hr (per engine)	1.55E-02
N2O	lb/hr (per engine)	3.10E-03
CO2e	lb/hr (per engine)	326.5

	Short Term Emissions (lb/hr)	Annual Emissions (tons/yr)
NOx	1.47	0.37
CO	71.65	17.91
VOC	0.02	4.92E-03
PM10	0.02	5.57E-03
PM2.5	0.02	5.57E-03
SO2	1.38E-03	3.45E-04
HAP	0.08	0.02
CO2	325.14	81
CH4	0.02	3.88E-03
N2O	3.10E-03	7.76E-04
CO2e	326.45	82

Notes:

1. Engine power rating is based on project assumption.
2. It is assumed that the 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, and VOC based on Tier 2 standards in 40 CFR 1048.101, paragraph (a)(2).
4. NOx+NMHC limit is 2.7 g/kWh; split into NOx and VOC based on NOx and VOC fractions in AP-42 Table 3.2-3 for four-stroke rich-burn natural gas-fired engines.
5. Emission factors for PM10, PM2.5, SO2, and HAP are from AP-42, Table 3.2-3 for four-stroke rich-burn natural gas-fired engines.
6. Emission factors used to calculate emission rates for CO2 (62.87 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.
7. CO2e emission rates use the following carbon equivalence factors: 25 for CH4, and 298 for N2O.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Onshore Switching Station and Substation Switchgear SF6 Emissions

Switching Station Circuit Breaker SF_6 [1] Fugitive Emissions

Total SF_6 Storage Capacity [2]	lbs	26,000.0
SF_6 Leak Rate (by weight) [3]	% per year	0.5%
SF_6 Emissions	lbs/year	130.00
SF_6 Emissions	tons/year	0.0650
Annual GHG emissions (CO_2e) [4]	tons/year	1,482.00

Onshore Substation Circuit Breaker SF_6 [1] Fugitive Emissions

Total SF_6 Storage Capacity [2]	lbs	35,137.0
SF_6 Leak Rate (by weight) [3]	% per year	0.5%
SF_6 Emissions	lbs/year	175.69
SF_6 Emissions	tons/year	0.0878
Annual GHG emissions (CO_2e) [4]	tons/year	2,002.81

1. SF_6 = Sulfur Hexafluoride
2. Storage capacity based on estimated provided by the project.
3. Leak rate for the SF6 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. CO_2e emission rates use the following carbon equivalence factors based on Table A-1 to Subpart A of 40 CFR Part 98—Global Warming Potentials: 22,800 for SF6.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Emission Factors

Commercial Marine Vessels (CMVs)

		Commercial Marine Vessel Emission Factors (g/hp-hr) /a									Fuel Cons.
	Engine Type	VOC	NO_x	CO	PM/ PM_{10} /b, /c	$PM_{2.5}$ /b	SO_2 /d	CO_2	CH_4	N_2O	(gal/hp-hr) /e
1	Category 1 engines < 1000 kW	0.20	7.3	3.73	0.19	0.19	0.0049	515	0.067	0.015	0.050
2	Category 2 engines	0.37	7.3	3.73	0.46	0.45	0.0049	515	0.067	0.015	0.050
3	Category 3 engines (MSD using MDO) (>30L/cyl.)	0.37	9.8	0.82	0.14	0.13	0.296	482	0.003	0.023	0.046
4	All Categories aux. engines (MSD using MDO)	0.30	10.4	0.82	0.14	0.13	0.316	515	0.003	0.023	0.049

/a Emission factors for Category 1 and 2 engines are from Table 3-8 and Category 3 engines are from Tables 2-9, 2-13, and 2-16 from ICF International report to the U.S. EPA, "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories", April 2009 (converted from g/kW-hr to g/hp-hr by multiplying by 0.746 kW/hp). Assumed all Category 1 and 2 engines to be used for for CVOW are certified to meet EPA Tier 1 and 2 marine engine standards respectively (providing conservative estimate for Category 1 engines); therefore the Tier 1 and 2 emission factors in Table 3-8 from the ICF International report was used.

/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 PM_{10} Emission factors for Category 1 and 2 engines presented in Table 3-8 of the ICF report (ICF International 2009) are based on a fuel sulfur content of 1.5 percent. These factors were adjusted for two potential fuel sulfur contents that could be used by marine vessels: 0.1 percent sulfur MARPOL-compliant marine fuel, and 0.0015 percent ultra-low sulfur distillate (ULSD) fuel oil. The ICF factors were adjusted for each fuel sulfur content following the approach used in Section 3.4.2 of the ICF Report. For 0.1 percent sulfur MARPOL-compliant marine fuel, the ICF factors were multiplied by 1.00 for PM10. For 0.0015 percent sulfur ULSD fuel oil, the ICF factors were multiplied by 0.86 for PM10.

/d SO2 emission factors for all marine engine categories are based on a mass balance calculation for the appropriate fuel sulfur content of each fuel: 0.1 percent sulfur MARPOL-compliant marine fuel, and 0.0015 percent ultra-low sulfur distillate (ULSD) fuel oil. The fuel consumption rate for each engine type was converted to a mass of fuel using an assumed fuel density of 853 kg/m3 (7.11 lb/gal).

/e Fuel consuption rate for category 1 and 2 marine engines was estimated based on CO_2 emission factor (g/hp-hr) and the emission factor for the mass of CO_2 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. Fuel consumption for Category 3 marine engines was based on the BSFC (g/kW-hr) in the ICF International report.

Land-based Nonroad Engines and Other Equipment (Virginia Beach, VA)

				NONROAD Emission Factors (g/hp-hr) /a								Climate Leaders (g/kWh) /b		NONROAD
	NONROAD Source Category			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	Fuel Consumption gal/hp-hr /c	Default Load Factor
	SCC	Description	Engine Size (hp)											
	Construction & Mining Subcategory (*002*)													
100	2270002033	Diesel Bore/Drill Rigs	175 < HP <= 300	0.33	4.17	0.91	0.20	0.19	0.005	530	0.017	0.013	0.052	43%
101	2270002036	Diesel Excavators	175 < HP <= 300	0.01	0.19	0.05	0.01	0.01	0.004	537	0.001	0.014	0.053	59%
102	2270002045	Diesel Cranes	300 < HP <= 600	0.07	1.29	0.31	0.05	0.05	0.004	531	0.004	0.014	0.052	43%
103	2270002057	Diesel Rough Terrain Forklifts	100 < hp <= 175	0.05	0.55	0.20	0.04	0.04	0.004	537	0.003	0.014	0.053	59%
104	2270002060	Diesel Rubber Tire Loaders	175 < hp <= 300	0.03	0.32	0.11	0.02	0.02	0.004	537	0.002	0.014	0.053	59%
105	2270002069	Diesel Crawler Tractor/Dozers	750 < hp <= 1000	0.07	2.65	0.26	0.05	0.05	0.004	537	0.004	0.014	0.053	59%
105.1	2270002075	Diesel Off-Highway Tractor	300 < HP <= 600	0.04	0.75	0.27	0.04	0.04	0.004	537	0.003	0.014	0.053	59%
105.2	2270002081	Diesel Other Construction Equip.	100 < hp <= 175	0.06	0.69	0.23	0.05	0.05	0.004	537	0.004	0.014	0.053	59%
	Industrial Equipment Subcategory (*003*)													
106	2270003010	Diesel Aerial Lifts	16 < hp <= 25	0.99	4.68	3.85	0.50	0.49	0.006	693	0.034	0.018	0.068	21%
	Commercial Equipment Subcategory (*006*)													
107	2270006005	Diesel Generator Sets	100 < HP <= 175	0.19	2.35	0.68	0.15	0.14	0.004	530	0.008	0.014	0.052	43%
108	2270006015	Diesel Air Compressors	100 < HP <= 175	0.05	0.89	0.21	0.05	0.05	0.004	531	0.004	0.014	0.052	43%

/a Emission factors for the land-based nonroad engines were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2024.

/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.

Land-based Nonroad Engines and Other Equipment (Chesapeake, VA)

	NONROAD Source Category			NONROAD Emission Factors (g/hp-hr) /a								Climate Leaders (g/kWh) /b	Fuel Consumption gal/hp-hr /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	2270002033	Diesel Bore/Drill Rigs	175 < HP <= 300	0.33	4.17	0.91	0.20	0.19	0.005	530	0.017	0.013	0.052	43%
111	2270002036	Diesel Excavators	175 < HP <= 300	0.01	0.19	0.05	0.01	0.01	0.004	537	0.001	0.014	0.053	59%
112	2270002045	Diesel Cranes	300 < HP <= 600	0.07	1.29	0.31	0.05	0.05	0.004	531	0.004	0.014	0.052	43%
113	2270002057	Diesel Rough Terrain Forklifts	100 < hp <= 175	0.05	0.55	0.20	0.04	0.04	0.004	537	0.003	0.014	0.053	59%
114	2270002060	Diesel Rubber Tire Loaders	175 < hp <= 300	0.03	0.32	0.11	0.02	0.02	0.004	537	0.002	0.014	0.053	59%
115	2270002069	Diesel Crawler Tractor/Dozers	750 < hp <= 1000	0.07	2.65	0.26	0.05	0.05	0.004	537	0.004	0.014	0.053	59%
115.1	2270002075	Diesel Off-Highway Tractor	300 < HP <= 600	0.04	0.75	0.27	0.04	0.04	0.004	537	0.003	0.014	0.053	59%
115.2	2270002081	Diesel Other Construction Equip.	100 < hp <= 175	0.06	0.69	0.23	0.05	0.05	0.004	537	0.004	0.014	0.053	59%
	Industrial Equipment Subcategory (*003*)													
116	2270003010	Diesel Aerial Lifts	16 < hp <= 25	0.99	4.68	3.85	0.50	0.49	0.006	693	0.034	0.018	0.068	21%
	Commercial Equipment Subcategory (*006*)													
117	2270006005	Diesel Generator Sets	100 < HP <= 175	0.19	2.35	0.68	0.15	0.14	0.004	530	0.008	0.014	0.052	43%
118	2270006015	Diesel Air Compressors	100 < HP <= 175	0.05	0.89	0.21	0.05	0.05	0.004	531	0.004	0.014	0.052	43%

/a Emission factors for the land-based nonroad engines were estimated using EPA's MOVES2014b emission model for an assumed construction year of 2024.

/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.

On-road Vehicles (Virginia Beach, VA)

			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		0.00077	0.00450	0.00337	0.00017	0.00016	0.00002	0.00010	2.70454	0.00034	0.00001	2.71066	8.32
132	Diesel Refuse Truck		0.00075	0.01008	0.00599	0.00040	0.00037	0.00003	0.00008	3.78889	0.00020	0.00001	3.79252	5.94
133	Diesel Light Commercial Truck		0.00141	0.00345	0.01136	0.00015	0.00014	0.00001	0.00015	1.52405	0.00031	0.00001	1.52922	14.77
134	Diesel Passenger Truck		0.00071	0.00221	0.00608	0.00006	0.00006	0.00001	0.00010	1.46838	0.00032	0.00001	1.47325	15.33
135	Gasoline Passenger Truck		0.00096	0.00097	0.01261	0.00002	0.00002	0.00002	0.00009	0.93708	0.00004	0.00003	0.94560	20.66

/a Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014b model and inputs for calendar year 2024 using the latest input files for calendar year 2017 from the Virginia Department of Environmental Quality.

On-road Vehicles (Chesapeake, VA)

			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		0.00064	0.00342	0.00295	0.00012	0.00011	0.00002	0.00009	2.13151	0.00031	0.00001	2.13571	10.56
142	Diesel Refuse Truck		0.00027	0.00302	0.00270	0.00006	0.00005	0.00003	0.00004	3.65182	0.00018	0.00000	3.65478	6.16
143	Diesel Light Commercial Truck		0.00108	0.00291	0.00966	0.00013	0.00012	0.00001	0.00011	1.25087	0.00021	0.00000	1.25400	17.99
144	Diesel Passenger Truck		0.00061	0.00208	0.00644	0.00007	0.00006	0.00001	0.00008	1.31987	0.00023	0.00000	1.32328	17.05
145	Gasoline Passenger Truck		0.00079	0.00107	0.01298	0.00002	0.00002	0.00002	0.00008	0.84307	0.00004	0.00002	0.84884	22.96

/a Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014b model and inputs for calendar year 2024 using the latest input files for calendar year 2017 from the Virginia Department of Environmental Quality.

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.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT
MOVES Emission Factor Summary

Virginia Beach, VA													
Input Year	Fuel	Vehicle Type	Emission Factor lbs/VMT										
			VOC	NOx	CO	PM10	PM2.5	SO2	HAPS	CO2	CH4	N2O	CO2e
2024	Diesel	Combination Long-haul Truck	2.95E-04	4.69E-03	1.32E-03	1.41E-04	1.29E-04	3.24E-05	2.78E-05	3.88	1.03E-04	4.43E-06	3.88
		Combination Short-haul Truck	3.34E-04	4.85E-03	1.94E-03	1.31E-04	1.21E-04	3.25E-05	3.53E-05	3.88	1.36E-04	4.81E-06	3.89
		Single Unit Long-haul Truck	5.62E-04	3.59E-03	3.17E-03	1.48E-04	1.36E-04	1.94E-05	7.23E-05	2.31	2.50E-04	7.59E-06	2.31
		Single Unit Short-haul Truck	7.66E-04	4.50E-03	3.37E-03	1.74E-04	1.60E-04	2.27E-05	9.93E-05	2.70	3.38E-04	1.00E-05	2.71
		Refuse Truck	7.48E-04	1.01E-02	5.99E-03	4.03E-04	3.70E-04	3.22E-05	7.65E-05	3.79	2.05E-04	5.74E-06	3.79
		Light Commercial Truck	1.41E-03	3.45E-03	1.14E-02	1.52E-04	1.40E-04	1.30E-05	1.48E-04	1.52	3.13E-04	7.06E-06	1.53
		Passenger Truck	7.08E-04	2.21E-03	6.08E-03	6.47E-05	5.95E-05	1.23E-05	9.52E-05	1.47	3.22E-04	6.65E-06	1.47
		Passenger Car	4.28E-04	2.84E-04	6.84E-03	1.04E-05	9.53E-06	5.55E-06	8.23E-05	0.66	3.85E-04	1.77E-06	0.67
	Gasoline	Combination Short-haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Single Unit Long-haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Single Unit Short-haul Truck	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Refuse Truck	2.74E-03	2.65E-03	1.30E-02	7.93E-05	7.01E-05	6.77E-05	3.64E-04	3.33	6.10E-05	1.85E-05	3.33
		Light Commercial Truck	2.76E-03	2.50E-03	2.64E-02	4.58E-05	4.05E-05	2.15E-05	2.70E-04	1.05	8.85E-05	6.70E-05	1.07
		Passenger Truck	9.60E-04	9.67E-04	1.26E-02	2.35E-05	2.07E-05	1.91E-05	9.35E-05	0.94	4.02E-05	3.11E-05	0.95
		Passenger Car	9.23E-04	6.59E-04	9.60E-03	1.92E-05	1.70E-05	1.43E-05	9.33E-05	0.70	2.52E-05	2.33E-05	0.71

Note: Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014b model and inputs for calendar year 2024 using the latest input files for calendar year 2017 from the Virginia Department of Environmental Quality.

Chesapeake, VA													
Input Year	Fuel	Vehicle Type	Emission Factor lbs/VMT										
			VOC	NOx	CO	PM10	PM2.5	SO2	HAPS	CO2	CH4	N2O	CO2e
2024	Diesel	Combination Long-haul Truck	2.74E-04	4.49E-03	1.37E-03	1.24E-04	1.14E-04	3.10E-05	2.55E-05	3.70	9.59E-05	3.72E-06	3.70
		Combination Short-haul Truck	3.36E-04	4.25E-03	2.35E-03	1.08E-04	9.94E-05	3.08E-05	3.75E-05	3.68	1.48E-04	4.30E-06	3.68
		Single Unit Long-haul Truck	4.66E-04	2.75E-03	2.80E-03	1.01E-04	9.30E-05	1.69E-05	6.36E-05	2.02	2.38E-04	5.74E-06	2.02
		Single Unit Short-haul Truck	6.39E-04	3.42E-03	2.95E-03	1.16E-04	1.06E-04	1.79E-05	8.69E-05	2.13	3.13E-04	7.49E-06	2.14
		Refuse Truck	2.73E-04	3.02E-03	2.70E-03	5.93E-05	5.46E-05	3.04E-05	3.73E-05	3.65	1.85E-04	4.04E-06	3.65
		Light Commercial Truck	1.08E-03	2.91E-03	9.66E-03	1.30E-04	1.19E-04	1.07E-05	1.10E-04	1.25	2.07E-04	3.98E-06	1.25
		Passenger Truck	6.12E-04	2.08E-03	6.44E-03	6.65E-05	6.11E-05	1.11E-05	7.63E-05	1.32	2.33E-04	4.16E-06	1.32
		Passenger Car	3.30E-04	2.92E-04	7.10E-03	1.02E-05	9.35E-06	4.93E-06	6.25E-05	0.59	2.90E-04	1.09E-06	0.59
	Gasoline	Combination Short-haul Truck	3.34E-02	3.32E-02	8.55E-01	1.14E-03	1.01E-03	7.71E-05	3.49E-03	3.73	6.90E-04	1.05E-03	4.07
		Single Unit Long-haul Truck	4.50E-03	5.27E-03	1.28E-01	1.52E-04	1.34E-04	4.62E-05	5.00E-04	2.27	1.63E-04	1.15E-04	2.29
		Single Unit Short-haul Truck	1.90E-03	2.91E-03	6.05E-02	7.52E-05	6.65E-05	4.59E-05	2.18E-04	2.25	9.00E-05	6.03E-05	2.27
		Refuse Truck	2.23E-03	1.40E-03	5.30E-03	8.20E-05	7.26E-05	6.48E-05	3.08E-04	3.18	4.91E-05	1.56E-05	3.19
		Light Commercial Truck	1.87E-03	2.19E-03	2.03E-02	4.30E-05	3.80E-05	1.73E-05	1.81E-04	0.85	6.46E-05	4.35E-05	0.86
		Passenger Truck	7.91E-04	1.07E-03	1.30E-02	2.46E-05	2.17E-05	1.72E-05	7.65E-05	0.84	3.57E-05	2.21E-05	0.85
		Passenger Car	7.01E-04	6.27E-04	8.65E-03	1.86E-05	1.65E-05	1.25E-05	7.05E-05	0.61	2.12E-05	1.61E-05	0.62

Note: Emission factors (lb/VMT) for VOC, NOx, CO, PM10, SO2, HAP and CO2e, were derived using the MOVES2014b model and inputs for calendar year 2024 using the latest input files for calendar year 2017 from the Virginia Department of Environmental Quality.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT
EPA NEI HAP emission factors for Commercial Marine Vessels

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.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT

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.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT

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.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT

HAP Emission Factor Calculation Sheet

Natural Gas-Fired Engines

Pollutant	Emission Factor (lb/MMBtu)[a]	Emission Factor Rating	Source (AP-42 Table)
1,1,2,2-Tetrachloroethane	2.53E-05	C	3.2-3
1,1,2-Trichloroethane	< 1.53E-05	E	3.2-3
1,3-Butadiene	6.63E-04	D	3.2-3
1,3-Dichloropropene	< 1.27E-05	E	3.2-3
Acetaldehyde	2.79E-03	C	3.2-3
Acrolein	2.63E-03	C	3.2-3
Benzene	1.58E-03	B	3.2-3
Carbon Tetrachloride	< 1.77E-05	E	3.2-3
Chlorobenzene	< 1.29E-05	E	3.2-3
Chloroform	< 1.37E-05	E	3.2-3
Ethylbenzene	< 2.48E-05	E	3.2-3
Ethylene Dibromide	< 2.13E-05	E	3.2-3
Formaldehyde	2.05E-02	A	3.2-3
Methanol	3.06E-03	D	3.2-3
Methylene Chloride	4.12E-05	C	3.2-3
Naphthalene	< 9.71E-05	E	3.2-3
PAH	1.41E-04	D	3.2-3
Styrene	< 1.19E-05	E	3.2-3
Toluene	5.58E-04	A	3.2-3
Vinyl Chloride	< 7.18E-06	E	3.2-3
Xylene	1.95E-04	A	3.2-3
Total for substances identified as HAP[e]	< 3.24E-02		

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

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT
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.