JULY 31 | 2023

Appendix N: Air Emissions Calculations and Methodology

Coastal Virginia Offshore Wind Commercial Project

Dominion Energy®

Submitted by:
Dominion Energy Services, Inc.
600 East Canal Street,
Richmond, VA 23219

Prepared by:
Tetra Tech, Inc.
4101 Cox Road, Suite 120
Glen Allen, VA 23060

Submitted To:
Bureau of Ocean Energy Management
45600 Woodland Road
Sterling, VA 20166

APPENDIX N AIR EMISSIONS CALCULATIONS AND METHODOLOGY REVISION LOG

Revision Number	Date	Description	Signed
1	12/2020	Initial release	Tetra Tech
2	6/2021	Updated based on BOEM comments and Project updates	Tetra Tech
3	10/2021	Updated based on BOEM comments and Project updates	Tetra Tech
4	5/2022	Updated based on BOEM comments and Project updates	Tetra Tech
5	2/2023	Updated based on BOEM comments and Project updates	Tetra Tech
6	7/2023	Updated based on Project updates	Tetra Tech

TABLE OF CONTENTS

N.1 Introduction N-1

N.2 Emission Calculation Methods N-2

N.2.1 Commercial Marine Vessels N-2

N.2.1.1 Default Emission Factors N-9

N.2.1.2 EPA Tier 2, Tier 3, and Tier 4 Marine Engine Standards N-10

N.2.1.3 Load Factors N-11

N.2.1.4 Calculation of Emissions N-11

N.2.2 Stationary Engines N-11

N.2.2.1 Offshore Substation and Onshore Generator Engines N-11

N.2.3 Nonroad Engines N-12

N.2.4 On-Road Vehicles N-13

N.2.5 Helicopters N-13

N.2.6 Gas-Insulated Switchgear N-14

N.2.7 Global Warming Potentials N-14

N.3 Geographic Allocation of Emissions N-14

N.3.1 Vessel Transits to Shore N-15

N.3.2 Nearshore Export Cable Construction N-16

N.3.3 Farshore Export Cable Construction N-16

N.3.4 All Other Vessel Activities N-16

N.4 Onshore Construction, Operations and Maintenance N-16

N.5 Summary of Emissions by Geographic Area N-16

N.6 References N-19

TABLES

Table N-1. Summary of Emission Factors used for Marine Vessels and Portable Generators (Construction and O&M) N-4
Table N-2. Construction Emissions for Calendar Year 2023 (tons) N-16
Table N-3. Construction Emissions for Calendar Year 2024 (tons) N-17
Table N-4. Construction Emissions for Calendar Year 2025 (tons) N-17
Table N-5. Construction Emissions for Calendar Year 2026 (tons) N-17
Table N-6. Construction Emissions for Calendar Year 2027 (tons) N-18
Table N-7. Operation and Maintenance Emissions for Calendar Year 2028 Onward (tons) N-18

FIGURES

Figure N-1. Project Area Overview N-3

ATTACHMENTS

Attachment N-1 Emission Calculations

ACRONYMS AND ABBREVIATIONS

BOEM	Bureau of Ocean Energy Management
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

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 (BOEM) 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 five categories of sources for which emissions were calculated:

- Commercial marine vessels (CMVs);
- 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.2.6. Section N.2.7 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

Emissions from marine vessels used for Project construction and operations and maintenance (O&M) have been estimated using a combination of default emission factors and U.S. Environmental Protection Agency (EPA) tier marine emission standards, as discussed below. Table N-1 presents a summary of the emission factors used for each type of marine vessel or portable generator engine anticipated to be used during construction and O&M. 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 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.

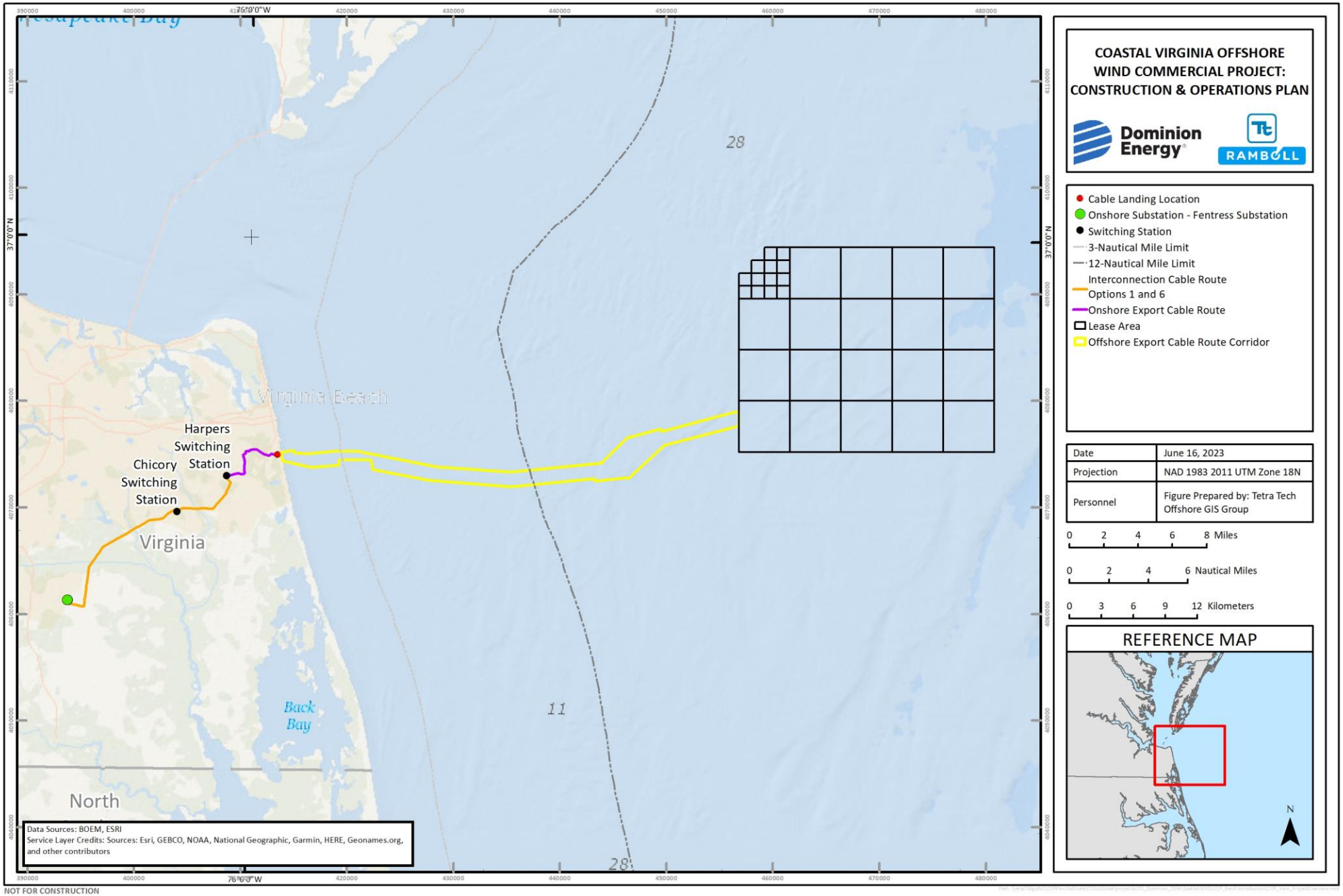

Figure N-1. Project Area Overview

Table N-1. Summary of Emission Factors used for Marine Vessels and Portable Generators (Construction and O&M)

Vessel/Equipment	Source of Factors	Emission Factor (g/kWh) a/, b/								
		VOC	NO_X	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2 c/	CO_2 d/, e/	CH_4 d/, e/	N_2O d/, e/
FOUNDATION INSTALLATION										
Fall Pipe Vessels										
Main generators	EPA Tier 2 - Cat 3 (model year 2011-2015)	0.50	9.7	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Aux. generators	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Heavy Lift Vessel (MP/TP)										
Main engines	EPA Tier 3 - Cat 3 (model year 2016-later)	0.50	2.4	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Aux. generators	EPA Tier 4 - Cat 1/Cat 2 (600 ≤ kW < 1400)	0.19	1.8	5.0	0.04	0.04	0.0065	690	0.09	0.02
Bubble Curtain Vessel										
Main engines	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Noise Monitoring Vessels										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Tugs for Barges										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Barge ballast pumps	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
OFFSHORE SUBSTATION TOPSIDE INSTALLATION										
Heavy Lift Vessel										
Main engines	EPA Tier 3 - Cat 3 (model year 2016-later)	0.50	2.4	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Aux. generators	EPA Tier 4 - Cat 1/Cat 2 (600 ≤ kW < 1400)	0.19	1.8	5.0	0.04	0.04	0.0065	690	0.09	0.02
Heavy Lift Deck Carrier										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Aux. generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Assist Tugboat										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Aux. generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02

Vessel/Equipment	Source of Factors	Emission Factor (g/kWh) a/, b/								
		VOC	NO_X	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2 c/	CO_2 d/, e/	CH_4 d/, e/	N_2O d/, e/
Offshore Substation Cable Pull-In Winch Generators	EPA Tier 4 stationary (56 ≤ kW < 130)	0.19	0.40	5.0	0.02	0.02	0.0064	694	0.028	0.006
Offshore Substation IAC Cable Termination Generators	EPA Tier 4 stationary (kW < 19)	0.93	6.57	6.6	0.40	0.39	0.0064	694	0.028	0.006
NEARSHORE EXPORT CABLE INSTALLATION										
Cable Lay Vessel										
Main generators	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Crane engine	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Tug for barge										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Barge ballast pumps	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Assist Tugboat										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Aux. generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Cable Lift Jack-Up Vessel										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Main crane engine	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Aux. crane engines	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Post-Lay Survey Vessel										
Main engines	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Aux. generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Crew Transfer Vessel										
Main engines	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Aux. generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
FARSHORE EXPORT CABLE INSTALLATION										
Cable Lay Vessel 1										
Main engines	EPA Tier 2 - Cat 3 (model year 2011-2015)	0.50	9.7	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Main engines	EPA Tier 2 - Cat 3 (model year 2011-2015)	0.50	9.7	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Aux. generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02

Vessel/Equipment	Source of Factors	Emission Factor (g/kWh) a/, b/								
		VOC	NO_X	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2 c/	CO_2 d/, e/	CH_4 d/, e/	N_2O d/, e/
Cable Lay Vessel 2										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Offshore Jointing Vessel										
Main engines	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
INTERARRAY CABLE INSTALLATION										
Cable Lay Vessel										
Main engines	EPA Tier 2 - Cat 3 (model year 2011-2015)	0.50	9.7	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Main engines	EPA Tier 2 - Cat 3 (model year 2011-2015)	0.50	9.7	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Aux. generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Burial tool	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Multi-Purpose Service Vessel										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Crew Transfer Vessel										
Main engines	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Pre-Lay Grapnel Run Vessel										
Main engines	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Pre-Lay Survey Vessel										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Post-Lay Survey Vessel										
Main engines	EPA Tier 2 - Cat 3 (model year 2011-2015)	0.50	9.7	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Main engines	EPA Tier 2 - Cat 3 (model year 2011-2015)	0.50	9.7	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Aux. generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
WTG INSTALLATION										
Charybdis Jack-Up Vessel										
Main engines	EPA Tier 3 - Cat 3 (model year 2016-later)	0.50	2.4	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Emergency generator	EPA Tier 4 - Cat 1/Cat 2 (600 ≤ kW < 1400)	0.19	1.8	5.0	0.04	0.04	0.0065	690	0.09	0.02
Walk-to-Work Vessel										
Main generators	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Aux. generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02

Vessel/Equipment	Source of Factors	Emission Factor (g/kWh) a/, b/								
		VOC	NO_X	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2 c/	CO_2 d/, e/	CH_4 d/, e/	N_2O d/, e/
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Tugs for barges										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Barge ballast pumps	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Assist Tugboat										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Aux. generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
WTG IAC Cable Termination Generators	EPA Tier 4 stationary (kW < 19)	0.93	6.57	6.6	0.40	0.39	0.0064	694	0.028	0.006
AUXILIARY VESSELS FOR CONSTRUCTION										
Sandwave Dredging Vessel										
Tugboat main engines	ICF Default Factors - Category 3 engines	0.50	13.2	1.1	0.19	0.18	0.3968	646.08	0.004	0.031
Tugboat harbor generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Tugboat emer. generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Dredger pump engines	ICF Default Factors - Category 3 engines	0.50	13.2	1.1	0.19	0.18	0.3968	646.08	0.004	0.031
Dredger harbor generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Boulder Picking Vessels										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Harbor generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Crossing Protection Vessel										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Harbor generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Boulder Ploughing Vessel										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Safety Vessel										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Main generators	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02

Vessel/Equipment	Source of Factors	Emission Factor (g/kWh) a/, b/								
		VOC	NO_X	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2 c/	CO_2 d/, e/	CH_4 d/, e/	N_2O d/, e/
OPERATIONS & MAINTENANCE										
Service Operations Vessel										
Main generators	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Crew Transfer Vessels										
Main engines	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Aux. generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Aux. engine	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Charybdis Jack-Up Vessel										
Main engines	EPA Tier 3 - Cat 3 (model year 2016-later)	0.50	2.4	5.0	0.19	0.18	0.3968	646.08	0.004	0.031
Emergency generator	EPA Tier 4 - Cat 1/Cat 2 (600 ≤ kW < 1400)	0.19	1.8	5.0	0.04	0.04	0.0065	690	0.09	0.02
Survey Vessel										
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Fall Pipe Vessel										
Main generators	ICF Default Factors - Category 3 engines	0.50	13.2	1.1	0.19	0.18	0.3968	646.08	0.004	0.031
Aux. generators	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 1 engines	0.27	9.8	5.0	0.26	0.25	0.0065	690	0.09	0.02
Cable Lay Vessel										
Main engines	ICF Default Factors - Category 3 engines	0.50	13.2	1.1	0.19	0.18	0.3968	646.08	0.004	0.031
Main engines	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Aux. generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02
Emergency generator	ICF Default Factors - Category 2 engines	0.50	9.8	5.0	0.62	0.60	0.0065	690	0.09	0.02

Notes:
a/ Where EPA has not established Tier 3 or 4 emission standards for CO from Category 1 and 2 engines, default factors from the ICF report were substituted.
b/ Where EPA has not established Category 3 emission standards for CO and PM, the default factors from the ICF report were substituted. For VOC, the default factor from the ICF report was used in lieu of the EPA Tier 3 HC standard.
c/ SO_2 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 sulfur for ULSD.
d/ GHG emission factors for Category 1 and 2 engines (CO_2, CH_4, and N_2O) are from Table 3-8 in the ICF report.
e/ GHG emission factors for Category 3 engines are from Table 2-9 (CO_2) and Table 2-13 (CH_4 and N_2O) in the ICF report.

N.2.1.1 Default Emission Factors

At this time, Dominion Energy does not have contracts in place for most of the specific marine vessels that will be used for Project construction and O&M. Therefore, it is not yet possible to know what specific marine engine emission standards these vessels will be subject to, since the applicable standards vary based on the construction year of a particular vessel and the rated power output and displacement for a given marine engine. For the construction and O&M activities where the specific marine vessel to be used is not yet known, potential emissions have been estimated using default emission factors from the April 2009 ICF International (ICF) report to EPA, "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories," providing a conservative estimate.

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;
- Jack-up vessels;
- Farshore export and inter-array cable lay vessels; and
- Sandwave removal vessel.

For these Category 3 engines, the analysis used the ICF emission factors for ocean-going vessels (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]).

For all engines, PM emissions are assumed to be less than 10 microns in diameter; therefore, PM emissions are equivalent to PM_{10} emissions. $PM_{2.5}$ is also a criteria pollutant and is estimated to be 97 percent of PM_{10}.[1]

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 EPA Tier 2, Tier 3, and Tier 4 Marine Engine Standards

Dominion Energy plans to use newer marine vessels that meet higher EPA Tier marine engine emission standards for several offshore construction and O&M tasks. Currently, the only vessel that has been specifically contracted by Dominion Energy for the CVOW Commercial Project is the Charybdis, which is a jack-up vessel to be used for the installation of the wind turbines. This vessel is currently under construction and will be the first Jones Act-compliant offshore wind turbine installation vessel in the U.S. that is designed to install current turbine technologies as well as next generation turbine sizes of 14 megawatts or larger, which are being proposed for the Project. Although contracts have not been finalized or put in place for the remaining vessels, Dominion Energy has identified certain fleets of vessels to be used for specific installation activities of the Project. Due to the specific nature of the work activity, as well as the limited number of vessels capable of meeting the required installation specifications and availability, the vessel categories described below are assumed to meet a specific EPA Tier, rather than using the default ICF emission factors.

- **Charybdis Jack-Up Vessel and other Heavy Lift Vessels.** Emissions from the Charybdis, which is under contract, and the other heavy lift vessels, which are not under contract, are based on the highest available EPA Tier marine engine standards for new vessels. The main engines will meet the EPA Tier 3 standards for Category 3 marine engines, and the emergency generator will meet the EPA Tier 4 standards for Category 1 and Category 2 marine engines rated between 600 and 1,400 kilowatts (kW).
- **Fall Pipe Vessels, Cable Lay Vessels, and Post-Lay Survey Vessel.** Although contracts are not yet in place for specific vessels, Dominion Energy expects that the main engines on these vessels

[1] U.S. Environmental Protection Agency. "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition," EPA420-R-10-018/NR-009d, July 2010.

will at a minimum meet the EPA Tier 2 standards for Category 3 marine engines (model years 2011-2015).

N.2.1.3 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.2.1.4 Calculation of Emissions

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

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

where:

E = emission, grams/year
kW = kilowatts (engine rating)
Act = activity, hours/year
LF = engine load factor (for the activity)
EF = emission factor, 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.2.7 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 permanent diesel generator engine rated at 563 kW mechanical output. The Onshore 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 non-emergency generation during construction commissioning activities, and only for emergencies during O&M. Potential emissions were estimated by assuming up to 7,320 operating hours for each engine during construction commissioning activities, and by conservatively assuming up to 500 operating hours per year for each engine, operating as an emergency engine, during O&M consistent with EPA guidance. These engines when operating as emergency engines during O&M will be limited to no more than 100 hours per year for non-emergency

purposes, which includes maintenance checks and readiness testing, but will not be limited during emergency operations. The onshore generator engines are assumed to be used only for emergency generation, as well as for readiness testing and maintenance purposes. For the 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.2.7.

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 may be used to perform crew transfers during commissioning of the Offshore Substations. 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 Norfolk International Airport as the assumed departure location. Emissions were based on two round trips per day, for a total of 294 operating days during calendar years 2024 and 2025, 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.

The Project may use a local port located in Chesapeake, Hampton, Newport News, Norfolk, or Portsmouth, 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 overseas port is assumed to be the starting point for transporting the jacket foundation and topside for each Offshore Substation platform.

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, Virginia (during construction) or Lambert's Point, Virginia (during O&M) 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: 27.0 nm (50.0 km)
    - Federal waters outside the OCS radius: 3.0 nm (5.6 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. 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 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.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 Facility 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)	1.34	19.53	5.30	0.98	0.95	0.06	0.32	8,565
Onshore (Chesapeake, VA)	0.37	8.35	1.39	0.28	0.27	0.02	0.09	2,652
Onshore Project Area (Portsmouth)	0.09	3.16	0.32	0.07	0.06	4.57E-03	0.02	657
Virginia state waters (Hampton Roads Air Quality Control Region)	0	0	0	0	0	0	0	0
Federal waters outside the Outer Continental Shelf radius	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inside Outer Continental Shelf radius	0	0	0	0	0	0	0	0
TOTAL, ALL AREAS	**1.80**	**31.05**	**7.01**	**1.32**	**1.28**	**0.08**	**0.43**	**11,873**

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)	2.68	39.06	10.59	1.96	1.90	0.12	0.64	17,129
Onshore (Chesapeake, VA)	0.75	16.70	2.79	0.56	0.54	0.04	0.18	5,304
Onshore (Norfolk, VA)	3.60E-02	2.64E-02	8.40E-04	7.56E-04	7.56E-04	4.20E-03	1.39E-04	13
Onshore Project Area (Portsmouth)	0.36	12.65	1.29	0.26	0.25	0.02	0.09	2,627
Virginia state waters (Hampton Roads Air Quality Control Region)	9.96	219.98	107.76	11.50	11.15	0.55	1.04	15,440
Federal waters outside the Outer Continental Shelf radius	0.13	3.24	1.16	0.10	0.10	0.05	1.26E-02	205
Inside Outer Continental Shelf radius	71.36	1,228.35	791.78	49.64	48.15	32.58	6.77	110,322
TOTAL, ALL AREAS	**85.27**	**1,520.02**	**915.36**	**64.02**	**62.10**	**33.36**	**8.73**	**151,042**

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)	2.01	29.30	7.94	1.47	1.43	0.09	0.48	12,847
Onshore (Chesapeake, VA)	0.37	8.35	1.39	0.28	0.27	0.02	0.09	2,652
Onshore (Norfolk, VA)	0.22	0.16	5.04E-03	4.54E-03	4.54E-03	0.03	8.34E-04	80
Onshore Project Area (Portsmouth)	0.56	16.35	2.44	0.45	0.43	0.03	0.14	4,873
Virginia state waters (Hampton Roads Air Quality Control Region)	28.02	573.91	303.66	31.33	30.39	2.56	2.90	42,709
Federal waters outside the Outer Continental Shelf radius	0.50	7.23	4.90	0.35	0.34	0.25	0.05	716
Inside Outer Continental Shelf radius	166.25	2,382.17	1,774.59	108.28	105.04	83.26	15.47	245,023
TOTAL, ALL AREAS	**197.95**	**3,017.47**	**2,094.93**	**142.16**	**137.89**	**86.24**	**19.12**	**308,900**

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	0	0	0	0	0	0	0
Onshore (Chesapeake, VA)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Onshore Project Area (Portsmouth)	0.36	8.10	1.86	0.31	0.30	0.03	0.09	3,651
Virginia state waters (Hampton Roads Air Quality Control Region)	6.28	72.16	60.35	3.98	3.86	3.45	0.59	8,578
Federal waters outside the Outer Continental Shelf radius	0.70	8.02	6.71	0.44	0.43	0.38	0.07	953
Inside Outer Continental Shelf radius	133.98	1,638.32	1,369.25	87.80	85.16	70.41	12.62	187,656
TOTAL, ALL AREAS	**141.32**	**1,726.60**	**1,438.15**	**92.53**	**89.76**	**74.27**	**13.36**	**200,838**

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)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Onshore (Chesapeake, VA)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Onshore Project Area (Portsmouth)	0.14	2.47	0.77	0.12	0.12	1.05E-02	0.03	1,497
Virginia state waters (Hampton Roads Air Quality Control Region)	2.59	29.65	24.91	1.64	1.59	1.43	0.24	3,541
Federal waters outside the Outer Continental Shelf radius	0.29	3.29	2.77	0.18	0.18	0.16	0.03	393
Inside Outer Continental Shelf radius	49.94	565.71	507.17	32.90	31.91	26.15	4.71	69,615
TOTAL, ALL AREAS	**52.96**	**601.13**	**535.61**	**34.84**	**33.79**	**27.75**	**5.01**	**75,047**

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	1.15	55.89	0.02	0.02	1.08E-03	0.06	1,737
Onshore (Chesapeake, VA)	0.02	1.28	62.33	0.02	0.02	1.20E-03	0.07	2,287
Onshore Project Area (Norfolk)	0.02	0.53	17.97	0.02	0.02	1.43E-03	0.02	241
Virginia state waters (Hampton Roads Air Quality Control Region)	0.42	7.36	4.96	0.32	0.31	0.16	0.04	675
Federal waters outside the Outer Continental Shelf radius	0.05	0.82	0.55	0.04	0.03	0.02	4.50E-03	75
Inside Outer Continental Shelf radius	23.01	385.21	277.17	17.93	17.39	8.01	2.22	40,261
TOTAL, ALL AREAS	**23.53**	**396.34**	**418.87**	**18.33**	**17.79**	**8.19**	**2.41**	**45,276**

N.6 REFERENCES

Blackman, J., M. Averyt, and Z. Taylor. 2017. *SF_6 Leak Rates from High Voltage Circuit Breakers – U.S. EPA Investigates Potential Greenhouse Gas Emissions Source*. Available online at: https://www.epa.gov/sites/production/files/2016-02/documents/leakrates_circuitbreakers.pdf. Accessed December 12, 2020.

BOEM (Bureau of Ocean Energy Management). 2017. *BOEM Offshore Wind Energy Facilities Emission Estimating Tool - Technical Documentation, OCS Study BOEM 2017-079, August 1, 2017.* Available online at: https://www.boem.gov/sites/default/files/renewable-energy-program/BOEM-Wind-Power-Technical-Documentation_2017_079-(1).pdf. Accessed April 20, 2022.

Entec (Entec UK Limited). 2002. *Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community*. Prepared for the European Commission. Available online at: https://ec.europa.eu/environment/air/pdf/chapter1_ship_emissions.pdf. Accessed December 12, 2020.

EPA (U.S. Environmental Protection Agency). 1995. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources*, Fifth Edition. Report No. AP-42. Available online at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=20005IRB.TXT. Accessed December 12, 2020.

EPA. 2005. *EPA's National Inventory Model (NMIM), A Consolidated Emissions Modeling System for MOBILE6 and NONROAD*. Report No. EPA420-R-05-024. Available online at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10023FZ.txt. Accessed December 12, 2020.

EPA. 2010. *Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling*. Report No. NR-005d.. Available online at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10081RV.txt. Accessed December 12, 2020.

EPA. 2014. "MOVES (Motor Vehicle Emission Simulator) and Other Mobile Source Emissions Models." Available online at: https://www.epa.gov/moves. Accessed December 12, 2020.

EPA. 2016. *Greenhouse Gas Inventory Guidance: Direct Emissions from Mobile Combustion Sources*. Report No. EPA430-K-16-004. Available online at: https://www.epa.gov/sites/production/files/2016-03/documents/mobileemissions_3_2016.pdf. Accessed December 12, 2020.

ICF (ICF International). 2009. *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*. Report No. 09-024 prepared for the U.S. Environmental Protection Agency. Available online at: https://www.epa.gov/sites/production/files/2016-06/documents/2009-port-inventory-guidance.pdf. Accessed December 12, 2020.

ATTACHMENT N-1: EMISSION CALCULATIONS

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Table N-1. Emission Summary

Potential Emissions

Calendar Year 2023	Total Emissions (tons per year)										
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)	1.34	19.53	5.30	0.98	0.95	0.06	0.32	8,498	0.09	0.21	8,565
Onshore (Chesapeake, VA)	0.37	8.35	1.39	0.28	0.27	0.02	0.09	2,632	0.02	0.07	2,652
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	652	5.41E-03	0.02	657
Virginia state waters (Hampton Roads AQCR)	0	0	0	0	0	0	0	0	0	0	0
Federal waters outside OCS radius	0	0	0	0	0	0	0	0	0	0	0
Inside OCS radius	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**1.80**	**31.05**	**7.01**	**1.32**	**1.28**	**0.08**	**0.43**	**11,782**	**0.11**	**0.30**	**11,873**

Calendar Year 2024	Total Emissions (tons per year)										
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)	2.68	39.06	10.59	1.96	1.90	0.12	0.64	16,997	0.18	0.43	17,129
Onshore (Chesapeake, VA)	0.75	16.70	2.79	0.56	0.54	0.04	0.18	5,263	0.04	0.13	5,304
Onshore (Norfolk, VA)	3.60E-02	2.64E-02	8.40E-04	7.56E-04	7.56E-04	4.20E-03	1.39E-04	13	3.36E-04	4.20E-04	13
Onshore (Portsmouth, VA)	0.36	12.65	1.29	0.26	0.25	0.02	0.09	2,607	0.02	0.07	2,627
Virginia state waters (Hampton Roads AQCR)	9.96	219.98	107.76	11.50	11.15	0.55	1.04	15,257	1.91	0.45	15,440
Federal waters outside OCS radius	0.13	3.24	1.16	0.10	0.10	0.05	1.26E-02	202	0.02	7.27E-03	205
Inside OCS radius	71.36	1,228.35	791.78	49.64	48.15	32.58	6.77	108,893	7.72	4.15	110,322
TOTAL	**85.27**	**1,520.02**	**915.36**	**64.02**	**62.10**	**33.36**	**8.73**	**149,233**	**9.88**	**5.24**	**151,042**

Calendar Year 2025	Total Emissions (tons per year)										
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)	2.01	29.30	7.94	1.47	1.43	0.09	0.48	12,748	0.13	0.32	12,847
Onshore (Chesapeake, VA)	0.37	8.35	1.39	0.28	0.27	0.02	0.09	2,632	0.02	0.07	2,652
Onshore (Norfolk, VA)	0.22	0.16	5.04E-03	4.54E-03	4.54E-03	0.03	8.34E-04	80	2.02E-03	2.52E-03	81
Onshore (Portsmouth, VA)	0.56	16.35	2.44	0.45	0.43	0.03	0.14	4,836	0.04	0.12	4,873
Virginia state waters (Hampton Roads AQCR)	28.02	573.91	303.66	31.33	30.39	2.56	2.90	42,198	5.06	1.29	42,709
Federal waters outside OCS radius	0.50	7.23	4.90	0.35	0.34	0.25	0.05	706	0.04	0.03	716
Inside OCS radius	166.25	2,382.17	1,774.59	108.28	105.04	83.26	15.47	241,876	14.13	9.37	245,023
TOTAL	**197.95**	**3,017.47**	**2,094.93**	**142.16**	**137.89**	**86.24**	**19.12**	**305,075**	**19.43**	**11.21**	**308,900**

Calendar Year 2026	Total Emissions (tons per year)										
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)	0.36	8.10	1.86	0.31	0.30	0.03	0.09	3,623	0.02	0.09	3,651
Virginia state waters (Hampton Roads AQCR)	6.28	72.16	60.35	3.98	3.86	3.45	0.59	8,463	0.41	0.35	8,578
Federal waters outside OCS radius	0.70	8.02	6.71	0.44	0.43	0.38	0.07	940	0.05	0.04	953
Inside OCS radius	133.98	1,638.32	1,369.25	87.80	85.16	70.41	12.62	185,163	10.04	7.52	187,656
TOTAL	**141.32**	**1,726.60**	**1,438.15**	**92.53**	**89.76**	**74.27**	**13.36**	**198,190**	**10.52**	**8.01**	**200,838**

Calendar Year 2027	Total Emissions (tons per year)										
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	1,486	9.14E-03	0.04	1,497
Virginia state waters (Hampton Roads AQCR)	2.59	29.65	24.91	1.64	1.59	1.43	0.24	3,494	0.17	0.15	3,541
Federal waters outside OCS radius	0.29	3.29	2.77	0.18	0.18	0.16	0.03	388	0.02	0.02	393
Inside OCS radius	49.94	565.71	507.17	32.90	31.91	26.15	4.71	68,690	3.72	2.79	69,615
TOTAL	**52.96**	**601.13**	**535.61**	**34.84**	**33.79**	**27.75**	**5.01**	**74,058**	**3.92**	**2.99**	**75,047**

Calendar Year 2028 Onward	Total Emissions (tons per year)										
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	1.15	55.89	0.02	0.02	1.08E-03	0.06	254	1.21E-02	2.42E-03	1,737
Onshore (Chesapeake, VA)	0.02	1.28	62.33	0.02	0.02	1.20E-03	0.07	283	1.35E-02	2.70E-03	2,287
Onshore (Norfolk, VA)	0.02	0.53	17.97	0.02	0.02	1.43E-03	0.02	240	4.88E-03	4.81E-03	241
Onshore (Portsmouth, VA)	0	0	0	0	0	0	0	0	0	0	0
Virginia state waters (Hampton Roads AQCR)	0.42	7.36	4.96	0.32	0.31	0.16	0.04	667	0.05	0.02	675
Federal waters outside OCS radius	0.05	0.82	0.55	0.04	0.03	0.02	4.50E-03	74	6.08E-03	2.69E-03	75
Inside OCS radius	23.01	385.21	277.17	17.93	17.39	8.01	2.22	37,525	3.27	1.32	40,261
TOTAL	**23.53**	**396.34**	**418.87**	**18.33**	**17.79**	**8.19**	**2.41**	**39,042**	**3.36**	**1.35**	**45,276**

Emissions for each calendar year were derived based on the indicative construction schedule for the Project.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Vessel Data Engines / Equipment	No. of Engines	1. DP 2.Anchored 3.Spuds	Emission Factor (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Average fuel rate (kg per day)	Fuel density (kg/gal)	Transit Data in OCS Boundary Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Transit Data outside OCS Boundary Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	OCS Boundary Outside Operating Days	Inside Operating Days	Non-Transit Data in OCS Boundary Operating Hours (hrs/day)	Total Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	OCS Boundary Total Fuel Usage (gal)
Foundations																									
Fall Pipe Vessel Scour protection (2024) 507 x 106 x 25 (25)	-Main Generator	4	1	3.02	5,230	Diesel	26,500	3.18	19	6	114	39,583	34%	19	0	0	0	0%	0	163	24	3,912	1,358,333	34%	1,397,917
	-Aux. Generator	1		2	1,332	Diesel			19	6	114			19	0	0			0	163	24	3,912			
	-Emergency Generator	1		1	253	Diesel			0	0	0			0	0	0			0	0	-	-			
Fall Pipe Vessel Scour protection (2025) 507 x 106 x 25 (25)	-Main Generator	4	1	3.02	5,230	Diesel	26,500	3.18	19	6	114	39,583	34%	19	0	0	0	0%	0	138	24	3,312	1,150,000	34%	1,189,583
	-Aux. Generator	1		2	1,332	Diesel			19	6	114			19	0	0			0	138	24	3,312			
	-Emergency Generator	1		1	253	Diesel			0	0	0			0	0	0			0	0	-	-			
Heavy Lift Vessel MP & TP installation 711 x 161 x 55 (36)	-Main Engines	4	1	3.03	13,820	Diesel	66,300	3.18	26	6	156	135,519	33%	26	0	0	0	0%	0	255	24	6,120	5,316,509	33%	5,452,028
	-Aux. Generators	2		4.01	1,100	Diesel			26	6	156			26	0	0			0	255	24	6,120			
Heavy Lift Vessel Pile driving equipment 711 x 161 x 55 (36)	-Vibrohammer Engines	2	1	2	3,029	Diesel	7,750	3.18	0	0	0	0	0%	0	0	0	0	0%	0	180	6	1,080	438,679	100%	438,679
	-Impact Hammer Engines	2		2	1,001	Diesel			0	0	0			0	0	0			0	180	6	1,080			
Bubble Curtain Vessel 454 x 100 x 29	-Main Engines	2	N/A	1	7,725	Diesel	42,000	3.18	7	6	42	23,113	35%	7	6	42	23,113	35%	0	132	24	3,168	1,743,396	35%	1,766,509
	-Main Generators	4		1	3,862	Diesel			7	6	42			7	6	42			0	132	24	3,168			
Noise Monitoring Vessel #1 84 x 34 x 10 (7)	-Main Engines	2	N/A	1	1,200	Diesel	5,000	3.18	7	6	42	2,752	53%	7	6	42	2,752	53%	0	132	24	3,168	207,547	53%	210,299
	-Main Generators	2		1	36	Diesel			7	6	42			7	6	42			0	132	24	3,168			
Noise Monitoring Vessel #2 84 x 34 x 10 (7)	-Main Engines	2	N/A	1	1,200	Diesel	5,000	3.18	7	6	42	2,752	53%	7	6	42	2,752	53%	0	132	24	3,168	207,547	53%	210,299
	-Main Generators	2		1	36	Diesel			7	6	42			7	6	42			0	132	24	3,168			
Tug 1 for MP/TP Barges 132 x 41 x 20 (18)	-Main Engines	2	N/A	2	3,245	Diesel	13,900	3.18	21	6	128	23,312	51%	21	6	128	23,312	51%	0	185	24	4,440	808,648	51%	831,960
	-Main Generators	2		1	289	Diesel			21	6	128			21	6	128			0	185	24	4,440			
	-Emergency Generator	1		1	133	Diesel			0	0	0			0	0	0			0	0	-	-			
Tug 2 for MP/TP Barges 132 x 41 x 20 (18)	-Main Engines	2	N/A	2	3,245	Diesel	13,900	3.18	21	6	128	23,312	51%	21	6	128	23,312	51%	0	185	24	4,440	808,648	51%	831,960
	-Main Generators	2		1	289	Diesel			21	6	128			21	6	128			0	185	24	4,440			
	-Emergency Generator	1		1	133	Diesel			0	0	0			0	0	0			0	0	-	-			
Tug 3 for MP/TP Barges 132 x 41 x 20 (18)	-Main Engines	2	N/A	2	3,245	Diesel	13,900	3.18	21	6	128	23,312	51%	21	6	128	23,312	51%	0	185	24	4,440	808,648	51%	831,960
	-Main Generators	2		1	289	Diesel			21	6	128			21	6	128			0	185	24	4,440			
	-Emergency Generator	1		1	133	Diesel			0	0	0			0	0	0			0	0	-	-			
MP/TP Barge 2 400 x 105 x 20	Ballast Pumps	12	N/A	1	44	Diesel	338	3.18	0	0	0	0	0%	0	0	0	0	0%	0	555	4	2,220	58,991	100%	58,991

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Non-Transit)											Total Emissions (Transit inside OCS Boundary)										
	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	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
Foundations																						
Fall Pipe Vessel Scour protection (2024) 507 x 106 x 25 (25)	12.10	234.60	120.99	5.11	4.96	9.04	1.08	15,697	0.22	0.73	15,921	0.35	6.84	3.53	0.15	0.14	0.26	0.03	457	6.45E-03	0.02	464
Fall Pipe Vessel Scour protection (2025) 507 x 106 x 25 (25)	10.24	198.62	102.43	4.33	4.20	7.65	0.92	13,289	0.19	0.62	13,479	0.35	6.84	3.53	0.15	0.14	0.26	0.03	457	6.45E-03	0.02	464
Heavy Lift Vessel MP & TP installation 711 x 161 x 55 (36)	46.33	226.90	474.54	17.06	16.55	36.24	4.09	61,478	0.69	2.90	62,360	1.18	5.78	12.10	0.43	0.42	0.92	0.10	1,567	0.02	0.07	1,590
Heavy Lift Vessel Pile driving equipment 711 x 161 x 55 (36)	3.58	70.12	35.78	4.43	4.30	0.05	0.38	4,937	0.64	0.14	4,996	0	0	0	0	0	0	0	0	0	0	0
Bubble Curtain Vessel 454 x 100 x 29	7.68	278.67	142.18	7.34	7.12	0.19	0.77	19,621	2.56	0.57	19,854	0.10	3.69	1.88	0.10	0.09	2.47E-03	1.02E-02	260	0.03	7.54E-03	263
Noise Monitoring Vessel #1 84 x 34 x 10 (7)	0.91	33.18	16.93	0.87	0.85	0.02	0.09	2,336	0.30	0.07	2,364	1.21E-02	0.44	0.22	1.16E-02	1.12E-02	2.93E-04	1.22E-03	31	4.04E-03	8.98E-04	31
Noise Monitoring Vessel #2 84 x 34 x 10 (7)	0.91	33.18	16.93	0.87	0.85	0.02	0.09	2,336	0.30	0.07	2,364	1.21E-02	0.44	0.22	1.16E-02	1.12E-02	2.93E-04	1.22E-03	31	4.04E-03	8.98E-04	31
Tug 1 for MP/TP Barges 132 x 41 x 20 (18)	6.35	129.26	65.95	7.78	7.54	0.09	0.67	9,101	1.19	0.26	9,209	0.18	3.73	1.90	0.22	0.22	2.49E-03	0.02	262	0.03	7.60E-03	265
Tug 2 for MP/TP Barges 132 x 41 x 20 (18)	6.35	129.26	65.95	7.78	7.54	0.09	0.67	9,101	1.19	0.26	9,209	0.18	3.73	1.90	0.22	0.22	2.49E-03	0.02	262	0.03	7.60E-03	265
Tug 3 for MP/TP Barges 132 x 41 x 20 (18)	6.35	129.26	65.95	7.78	7.54	0.09	0.67	9,101	1.19	0.26	9,209	0.18	3.73	1.90	0.22	0.22	2.49E-03	0.02	262	0.03	7.60E-03	265
MP/TP Barge 2 400 x 105 x 20	0.26	9.43	4.81	0.25	0.24	0.01	0.03	664	0.09	0.02	672	0	0	0	0	0	0	0	0	0	0	0

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Transit outside OCS Boundary)										
	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
Foundations											
Fall Pipe Vessel Scour protection (2024) 507 x 106 x 25 (25)	0	0	0	0	0	0	0	0	0	0	0
Fall Pipe Vessel Scour protection (2025) 507 x 106 x 25 (25)	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel MP & TP installation 711 x 161 x 55 (36)	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Vessel Pile driving equipment 711 x 161 x 55 (36)	0	0	0	0	0	0	0	0	0	0	0
Bubble Curtain Vessel 454 x 100 x 29	0.10	3.69	1.88	0.10	0.09	2.47E-03	1.02E-02	260	0.03	7.54E-03	263
Noise Monitoring Vessel #1 84 x 34 x 10 (7)	1.21E-02	0.44	0.22	1.16E-02	1.12E-02	2.93E-04	1.22E-03	31	4.04E-03	8.98E-04	31
Noise Monitoring Vessel #2 84 x 34 x 10 (7)	1.21E-02	0.44	0.22	1.16E-02	1.12E-02	2.93E-04	1.22E-03	31	4.04E-03	8.98E-04	31
Tug 1 for MP/TP Barges 132 x 41 x 20 (18)	0.18	3.73	1.90	0.22	0.22	2.49E-03	0.02	262	0.03	7.60E-03	265
Tug 2 for MP/TP Barges 132 x 41 x 20 (18)	0.18	3.73	1.90	0.22	0.22	2.49E-03	0.02	262	0.03	7.60E-03	265
Tug 3 for MP/TP Barges 132 x 41 x 20 (18)	0.18	3.73	1.90	0.22	0.22	2.49E-03	0.02	262	0.03	7.60E-03	265
MP/TP Barge 2 400 x 105 x 20	0	0	0	0	0	0	0	0	0	0	0

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Vessel Data								Transit Data in OCS Boundary					Transit Data outside OCS Boundary					OCS Boundary		Non-Transit Data in OCS Boundary				OCS Boundary
	Engines / Equipment	No. of Engines	1. DP 2.Anchored 3.Spuds	Emission Factor (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Average fuel rate (kg per day)	Fuel density (kg/gal)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Outside Operating Days	Inside Operating Days	Operating Hours (hrs/day)	Total Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Total Fuel Usage (gal)
OSS Jacket																									
Heavy Lift Vessel Jacket installation 710 x 161 x 55 (36)	-Main Engines	4	1	3.03	13,814	Diesel	66,300	3.18	2	6	12	10,425	32%	2	0	0	0	0%	0	40	24	960	833,962	32%	844,387
	-Aux. Generators	2		4.01	1,488	Diesel			2	6	12			2	0	0			0	40	24	960			
Bubble Curtain Vessel 454 x 100 x 29	-Main Engines	2	N/A	1	7,725	Diesel	42,000	3.18	2	6	12	6,604	35%	2	6	12	6,604	35%	0	40	24	960	528,302	35%	534,906
	-Main Generators	4		1	3,862	Diesel			2	6	12			2	6	12			0	40	24	960			
Noise Monitoring Vessel #1 84 x 34 x 10 (7)	-Main Engines	2	N/A	1	1,200	Diesel	5,000	3.18	2	6	12	786	53%	2	6	12	786	53%	0	40	24	960	62,893	53%	63,679
	-Main Generators	2		1	36	Diesel			2	6	12			2	6	12			0	40	24	960			
Noise Monitoring Vessel #2 84 x 34 x 10 (7)	-Main Engines	2	N/A	1	1,200	Diesel	5,000	3.18	2	6	12	786	53%	2	6	12	786	53%	0	40	24	960	62,893	53%	63,679
	-Main Generators	2		1	36	Diesel			2	6	12			2	6	12			0	40	24	960			
Heavy Lift Deck Carrier 173m x 42m	-Main Engines	2	N/A	2	3,862	Diesel	13,900	3.18	3	6	18	3,278	20%	3	6	18	3,278	20%	0	80	24	1,920	349,686	20%	352,964
	-Main Generators	2		1	5,150	Diesel			3	6	18			3	6	18			0	80	24	1,920			
	-Aux Generator	1		1	1,333	Diesel			0	0	0			0	0	0			0	0	24	-			
	-Aux Generator	1		1	806	Diesel			0	0	0			0	0	0			0	0	24	-			
Assist Tugboat 112 x 35 x 19 (19)	-Main Engines	2	N/A	2	2,675	Diesel	11,700	3.18	3	6	18	2,759	53%	3	6	18	2,759	53%	0	80	24	1,920	294,340	53%	297,099
	-Aux. Generators	2		1	201	Diesel			3	6	18			3	6	18			0	80	24	1,920			
OSS Topside																									
Heavy Lift Vessel Topside installation 710 x 161 x 55 (36)	-Main Engines	4	1	3.03	13,814	Diesel	66,300	3.18	3	6	18	15,637	32%	3	0	0	0	0%	0	11	24	264	229,340	32%	244,976
	-Aux. Generators	2		4.01	1,488	Diesel			3	6	18			3	0	0			0	11	24	264			
Heavy Lift Deck Carrier 173m x 42m	-Main Engines	2	N/A	2	3,862	Diesel	13,900	3.18	3	6	18	3,278	20%	3	6	18	3,278	20%	0	11	24	264	48,082	20%	51,360
	-Main Generators	2		1	5,150	Diesel			3	6	18			3	6	18			0	11	24	264			
	-Aux Generator	1		1	1,333	Diesel			0	0	0			0	0	0			0	0	0	0			
	-Aux Generator	1		1	806	Diesel			0	0	0			0	0	0			0	0	0	0			
Assist Tugboat 112 x 35 x 19 (19)	-Main Engines	2	N/A	2	2,675	Diesel	11,700	3.18	3	6	18	2,759	53%	3	6	18	2,759	53%	0	11	24	264	40,472	53%	43,231
	-Aux. Generators	2		1	201	Diesel			3	6	18			3	6	18			0	11	24	264			
Generators	OSS 1 Cable Pull-In Winch	1	N/A	256	80	Diesel	410	3.18	0	0	0	0	0%	0	0	0	0	0%	0	30	24	720	3,868	7%	3,868
	OSS 2 Cable Pull-In Winch	1	N/A	256	80	Diesel	410	3.18	0	0	0			0	0	0			0	30	24	720			
	OSS 3 Cable Pull-In Winch	1	N/A	256	80	Diesel	410	3.18	0	0	0			0	0	0			0	30	24	720			
	OSS IAC Cable Termination	10	N/A	254	20	Diesel	1,030	3.18	0	0	0			0	0	0			0	180	24	4320			
Helicopter - Twin-Engine Heavy	-Main Engines	2	N/A	164	1,400	Jet fuel	N/A	N/A	588	0.5	294	22,153		588	0.25	147	11,076		0	0	0	0			

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Non-Transit)											Total Emissions (Transit inside OCS Boundary)										
	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	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
OSS Jacket																						
Heavy Lift Vessel Jacket installation 710 x 161 x 55 (36)	7.20	35.43	74.34	2.64	2.57	5.60	0.64	9,639.86	0.12	0.45	9,777.85	0.09	0.44	0.93	0.03	0.03	0.07	7.94E-03	120.50	1.56E-03	5.66E-03	122.22
Bubble Curtain Vessel 454 x 100 x 29	2.33	84.45	43.08	2.22	2.16	0.06	0.23	5,946	0.78	0.17	6,016	0.03	1.06	0.54	0.03	0.03	7.04E-04	2.92E-03	74	9.69E-03	2.15E-03	75
Noise Monitoring Vessel #1 84 x 34 x 10 (7)	0.28	10.05	5.13	0.26	0.26	6.71E-03	0.03	708	0.09	0.02	716	3.46E-03	0.13	0.06	3.31E-03	3.21E-03	8.38E-05	3.48E-04	9	1.15E-03	2.56E-04	9
Noise Monitoring Vessel #2 84 x 34 x 10 (7)	0.28	10.05	5.13	0.26	0.26	6.71E-03	0.03	708	0.09	0.02	716	3.46E-03	0.13	0.06	3.31E-03	3.21E-03	8.38E-05	3.48E-04	9	1.15E-03	2.56E-04	9
Heavy Lift Deck Carrier 173m x 42m	2.10	55.90	28.52	2.35	2.28	0.04	0.22	3,935.50	0.51	0.11	3,982.33	0.02	0.52	0.27	0.02	0.02	3.50E-04	2.05E-03	36.90	4.81E-03	1.07E-03	37.33
Assist Tugboat 112 x 35 x 19 (19)	2.32	47.05	24.00	2.85	2.77	0.03	0.25	3,312.62	0.43	0.10	3,352.03	0.02	0.44	0.23	0.03	0.03	2.94E-04	2.31E-03	31.06	4.05E-03	9.00E-04	31.43
OSS Topside																						
Heavy Lift Vessel Topside installation 710 x 161 x 55 (36)	1.98	9.74	20.44	0.73	0.71	1.54	0.17	2,650.96	0.03	0.12	2,688.91	0.13	0.66	1.39	0.05	0.05	0.11	1.19E-02	180.75	2.34E-03	8.49E-03	183.33
Heavy Lift Deck Carrier 173m x 42m	0.29	7.69	3.92	0.32	0.31	5.13E-03	0.03	541.13	0.07	0.02	547.57	0.02	0.52	0.27	0.02	0.02	3.50E-04	2.05E-03	36.90	4.81E-03	1.07E-03	37.33
Assist Tugboat 112 x 35 x 19 (19)	0.32	6.47	3.30	0.39	0.38	4.32E-03	0.03	455.49	0.06	1.32E-02	460.90	0.02	0.44	0.23	0.03	0.03	2.94E-04	2.31E-03	31.06	4.05E-03	9.00E-04	31.43
Generators	0.03	0.88	0.07	1.15E-02	1.12E-02	0.03	2.27E-03	43.58	2.52E-04	1.96E-03	44.17	0	0	0	0	0	0	0	0	0	0	0
Helicopter - Twin-Engine Heavy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.46	1.47E-02	1.32E-02	1.32E-02	0.07	2.43E-03	233.68	5.88E-03	7.35E-03	236.02

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Transit outside OCS Boundary)										
	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
OSS Jacket											
Heavy Lift Vessel Jacket installation 710 x 161 x 55 (36)	0	0	0	0	0	0	0	0	0	0	0
Bubble Curtain Vessel 454 x 100 x 29	0.03	1.06	0.54	0.03	0.03	7.04E-04	2.92E-03	74	9.69E-03	2.15E-03	75
Noise Monitoring Vessel #1 84 x 34 x 10 (7)	3.46E-03	0.13	0.06	3.31E-03	3.21E-03	8.38E-05	3.48E-04	9	1.15E-03	2.56E-04	9
Noise Monitoring Vessel #2 84 x 34 x 10 (7)	3.46E-03	0.13	0.06	3.31E-03	3.21E-03	8.38E-05	3.48E-04	9	1.15E-03	2.56E-04	9
Heavy Lift Deck Carrier 173m x 42m	0.02	0.52	0.27	0.02	0.02	3.50E-04	2.05E-03	37	4.81E-03	1.07E-03	37
Assist Tugboat 112 x 35 x 19 (19)	0.02	0.44	0.23	0.03	0.03	2.94E-04	2.31E-03	31	4.05E-03	9.00E-04	31
OSS Topside											
Heavy Lift Vessel Topside installation 710 x 161 x 55 (36)	0	0	0	0	0	0	0	0	0	0	0
Heavy Lift Deck Carrier 173m x 42m	0.02	0.52	0.27	0.02	0.02	3.50E-04	2.05E-03	37	4.81E-03	1.07E-03	37
Assist Tugboat 112 x 35 x 19 (19)	0.02	0.44	0.23	0.03	0.03	2.94E-04	2.31E-03	31	4.05E-03	9.00E-04	31
Generators	0	0	0	0	0	0	0	0	0	0	0
Helicopter - Twin-Engine Heavy	0.31	0.23	7.35E-03	6.62E-03	6.62E-03	0.04	1.22E-03	116.84	2.94E-03	3.68E-03	118.01

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Vessel Data								Transit Data in OCS Boundary					Transit Data outside OCS Boundary					OCS Boundary		Non-Transit Data in OCS Boundary				OCS Boundary
	Engines / Equipment	No. of Engines	1. DP 2.Anchored 3.Spuds	Emission Factor (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Average fuel rate (kg per day)	Fuel density (kg/gal)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Outside Operating Days	Inside Operating Days	Operating Hours (hrs/day)	Total Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Total Fuel Usage (gal)
Nearshore Export Cable																									
Cable Lay Vessel	-Main Generators	4	N/A	2	1,332	Diesel	20,000	3.18	7	6	42	11,006	98%	7	6	42	11,006	98%	0	310	24	7,440	1,949,686	89%	1,960,692
	-Crane Engine	1		1	536	Diesel			0	0	0			0	0	0			0	310	24	7,440			
	-Emergency Generator	1		1	361	Diesel			0	0	0			0	0	0			0	0	-	0			
401 x 110 x 25 (18)																									
Tug for Barge	-Main Engines	2	N/A	2	3,634	Diesel	13,900	3.18	3	6	18	3,278	46%	3	6	18	3,278	46%	0	310	24	7,440	1,355,031	46%	1,358,310
	-Main Generators	2		1	288	Diesel			3	6	18			3	6	18			0	310	24	7,440			
	-Emergency Generator	1		1	133	Diesel			0	0	0			0	0	0			0	0	-	0			
132 x 41 x 20 (18)																									
Barge	Ballast Pumps	12	N/A	1	44	Diesel	2,030	3.18	3	6	18	479	100%	3	6	18	479	100%	0	321	24	7,704	204,915	100%	205,394
400 x 105 x 20																									
Assist Tugboat	-Main Engines	2	N/A	2	2,675	Diesel	11,700	3.18	2	6	12	1,840	53%	2	6	12	1,840	53%	0	80	24	1,920	294,340	53%	296,179
	-Aux. Generators	2		1	201	Diesel			2	6	12			2	6	12			0	80	24	1,920			
112 x 35 x 19 (19)																									
Cable Lift Jack-Up Installation Vessel	-Main Engines	2	3	2	2,682	Diesel	13,000	3.18	2	6	12	2,044	57%	2	6	12	2,044	57%	0	40	24	960	163,522	42%	165,566
	-Main Generators	2		1	288	Diesel			2	6	12			2	6	12			0	40	24	960			
	-Main Crane Engine	1		2	1,150	Diesel			0	0	0			0	0	0			0	40	24	960			
144 x 105 x 13 (13)	-Aux Crane Engines	2		1	490	Diesel			0	0	0			0	0	0			0	40	24	960			
Pre-Lay Grapnel Run Vessel	-Main Engines	2	N/A	1	3,000	Diesel	5,000	3.18	2	6	12	786	19%	2	6	12	786	19%	0	65	24	1,560	102,201	19%	102,987
	-Main Generators	2		1	341	Diesel			2	6	12			2	6	12			0	65	24	1,560			
	-Main Generators	2		1	1,878	Diesel			0	0	0			0	0	0			0	0	24	0			
81m x 18m	-Emerg Generators	1		1	120	Diesel			0	0	0			0	0	0			0	0	-	0			
Pre-Lay Survey Vessel	-Main Engines	2	N/A	1	2,347	Diesel	4,000	3.18	2	6	12	629	18%	2	6	12	629	18%	0	155	24	3,720	194,969	18%	195,597
	-Aux Generators	2		1	536	Diesel			2	6	12			2	6	12			0	155	24	3,720			
26.6m x 10.4m x 3.0m																									
Post-Lay Survey Vessel	-Main Engines	2	N/A	1	2,347	Diesel	4,000	3.18	2	6	12	629	18%	2	6	12	629	18%	0	32	24	768	40,252	18%	40,881
	-Aux Generators	2		1	536	Diesel			2	6	12			2	6	12			0	32	24	768			
26.6m x 10.4m x 3.0m																									
Crew Transfer Vessel	-Main Engines	2	N/A	1	2,347	Diesel	4,000	3.18	2	6	12	629	18%	2	6	12	629	18%	0	40	24	960	50,314	18%	50,943
	-Aux Generators	2		1	536	Diesel			2	6	12			2	6	12			0	40	24	960			
26.6m x 10.4m x 3.0m																									
Farshore Export Cable																									
Cable Lay Vessel	-Main engines	2	1	3.02	5,791	Diesel	22,000	3.18	18	6	108	31,132	30%	18	6	108	31,132	30%	0	110	24	2,640	761,006	30%	792,138
	-Main engines	2		3.02	3,861	Diesel			18	6	108			18	6	108			0	110	24	2,640			
	-Aux Gen	1		2	1,333	Diesel			18	6	108			18	6	108			0	110	24	2,640			
528 x 106 x 38	-Emerg Gen	1		2	588	Diesel			0	0	0			0	0	0			0	0	-	-			
Cable Lay Vessel	-Main Engines	6	1	2	3,085	Diesel	21,000	3.18	18	6	108	29,717	29%	18	6	108	29,717	29%	0	135	24	3,240	891,509	29%	921,226
																						0			
110 x 39 x 18 (9)																									
Pre-Lay Survey Vessel	-Main Engines	2	N/A	1	2,347	Diesel	4,000	3.18	103	6	618	32,390	18%	103	6	618	32,390	18%	0	12	24	288	15,094	18%	47,484
	-Aux Generators	2		1	536	Diesel			103	6	618			103	6	618			0	12	24	288			
26.6m x 10.4m x 3.0m																									
Offshore Jointing Vessel	-Main Engines	4	N/A	1	800	Diesel	8,000	3.18	12	6	72	7,547	64%	12	6	72	7,547	64%	0	14	24	336	35,220	64%	42,767
	-Main Generators	2		1	32	Diesel			12	6	72			12	6	72			0	14	24	336			
65 x 23 x 6 (6)																									

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Non-Transit)											Total Emissions (Transit inside OCS Boundary)										
	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	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
Nearshore Export Cabl																						
Cable Lay Vessel 401 x 110 x 25 (18)	15.23	311.65	159.00	18.64	18.08	0.21	1.61	21,943	2.86	0.64	22,204	0.09	1.76	0.90	0.11	0.11	1.17E-03	9.53E-03	124	0.02	3.59E-03	125
Tug for Barge 132 x 41 x 20 (18)	10.68	216.60	110.51	13.10	12.71	0.14	1.13	15,250	1.99	0.44	15,432	0.03	0.52	0.27	0.03	0.03	3.50E-04	2.74E-03	37	4.81E-03	1.07E-03	37
Barge 400 x 105 x 20	0.90	32.75	16.71	0.86	0.84	0.02	0.09	2,306	0.30	0.07	2,334	2.11E-03	0.08	0.04	2.01E-03	1.95E-03	5.11E-05	2.12E-04	5	7.03E-04	1.56E-04	5
Assist Tugboat 112 x 35 x 19 (19)	2.32	47.05	24.00	2.85	2.77	0.03	0.25	3,313	0.43	0.10	3,352	1.45E-02	0.29	0.15	0.02	0.02	1.96E-04	1.54E-03	21	2.70E-03	6.00E-04	21
Cable Lift Jack-Up Installation Vessel 144 x 105 x 13 (13)	1.22	26.14	13.34	1.47	1.42	0.02	0.13	1,840	0.24	0.05	1,862	0.02	0.33	0.17	0.02	0.02	2.18E-04	1.69E-03	23	3.00E-03	6.67E-04	23
Pre-Lay Grapnel Run Vessel 81m x 18m	0.45	16.34	8.33	0.43	0.42	1.09E-02	0.05	1,150	0.15	0.03	1,164	3.46E-03	0.13	0.06	3.31E-03	3.21E-03	8.38E-05	3.48E-04	9	1.15E-03	2.56E-04	9
Pre-Lay Survey Vessel 26.6m x 10.4m x 3.0m	0.86	31.16	15.90	0.82	0.80	0.02	0.09	2,194	0.29	0.06	2,220	2.77E-03	0.10	0.05	2.65E-03	2.57E-03	6.71E-05	2.78E-04	7	9.23E-04	2.05E-04	7
Post-Lay Survey Vessel 26.6m x 10.4m x 3.0m	0.18	6.43	3.28	0.17	0.16	4.29E-03	0.02	453	0.06	1.31E-02	458	2.77E-03	0.10	0.05	2.65E-03	2.57E-03	6.71E-05	2.78E-04	7	9.23E-04	2.05E-04	7
Crew Transfer Vessel 26.6m x 10.4m x 3.0m	0.22	8.04	4.10	0.21	0.21	5.37E-03	0.02	566	0.07	0.02	573	2.77E-03	0.10	0.05	2.65E-03	2.57E-03	6.71E-05	2.78E-04	7	9.23E-04	2.05E-04	7
Farshore Export Cable																						
Cable Lay Vessel 528 x 106 x 38	6.78	131.38	67.75	2.89	2.80	5.03	0.61	8,793	0.13	0.41	8,918	0.28	5.37	2.77	0.12	0.11	0.21	0.02	360	5.30E-03	0.02	365
Cable Lay Vessel 110 x 39 x 18 (9)	7.27	142.50	72.71	9.00	8.73	0.10	0.77	10,033	1.31	0.29	10,153	0.24	4.75	2.42	0.30	0.29	3.17E-03	0.03	334	0.04	9.69E-03	338
Pre-Lay Survey Vessel 26.6m x 10.4m x 3.0m	0.07	2.41	1.23	0.06	0.06	1.61E-03	6.67E-03	170	0.02	4.92E-03	172	0.14	5.18	2.64	0.14	0.13	3.45E-03	1.43E-02	365	0.05	1.06E-02	369
Offshore Jointing Vessel 65 x 23 x 6 (6)	0.16	5.63	2.87	0.15	0.14	3.76E-03	0.02	396	0.05	1.15E-02	401	0.03	1.21	0.62	0.03	0.03	8.05E-04	3.34E-03	85	1.11E-02	2.46E-03	86

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Transit outside OCS Boundary)										
	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
Nearshore Export Cabl											
Cable Lay Vessel 401 x 110 x 25 (18)	0.09	1.76	0.90	0.11	0.11	1.17E-03	9.53E-03	124	0.02	3.59E-03	125
Tug for Barge 132 x 41 x 20 (18)	0.03	0.52	0.27	0.03	0.03	3.50E-04	2.74E-03	37	4.81E-03	1.07E-03	37
Barge 400 x 105 x 20	2.11E-03	0.08	0.04	2.01E-03	1.95E-03	5.11E-05	2.12E-04	5	7.03E-04	1.56E-04	5
Assist Tugboat 112 x 35 x 19 (19)	1.45E-02	0.29	0.15	0.02	0.02	1.96E-04	1.54E-03	21	2.70E-03	6.00E-04	21
Cable Lift Jack-Up Installation Vessel 144 x 105 x 13 (13)	0.02	0.33	0.17	0.02	0.02	2.18E-04	1.69E-03	23	3.00E-03	6.67E-04	23
Pre-Lay Grapnel Run Vessel 81m x 18m	3.46E-03	0.13	0.06	3.31E-03	3.21E-03	8.38E-05	3.48E-04	9	1.15E-03	2.56E-04	9
Pre-Lay Survey Vessel 26.6m x 10.4m x 3.0m	2.77E-03	0.10	0.05	2.65E-03	2.57E-03	6.71E-05	2.78E-04	7	9.23E-04	2.05E-04	7
Post-Lay Survey Vessel 26.6m x 10.4m x 3.0m	2.77E-03	0.10	0.05	2.65E-03	2.57E-03	6.71E-05	2.78E-04	7	9.23E-04	2.05E-04	7
Crew Transfer Vessel 26.6m x 10.4m x 3.0m	2.77E-03	0.10	0.05	2.65E-03	2.57E-03	6.71E-05	2.78E-04	7	9.23E-04	2.05E-04	7
Farshore Export Cable											
Cable Lay Vessel 528 x 106 x 38	0.28	5.37	2.77	0.12	0.11	0.21	0.02	360	5.30E-03	0.02	365
Cable Lay Vessel 110 x 39 x 18 (9)	0.24	4.75	2.42	0.30	0.29	3.17E-03	0.03	334	0.04	9.69E-03	338
Pre-Lay Survey Vessel 26.6m x 10.4m x 3.0m	0.14	5.18	2.64	0.14	0.13	3.45E-03	1.43E-02	365	0.05	1.06E-02	369
Offshore Jointing Vessel 65 x 23 x 6 (6)	0.03	1.21	0.62	0.03	0.03	8.05E-04	3.34E-03	85	1.11E-02	2.46E-03	86

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Vessel Data								Transit Data in OCS Boundary					Transit Data outside OCS Boundary					OCS Boundary		Non-Transit Data in OCS Boundary				OCS Boundary
	Engines / Equipment	No. of Engines	1. DP 2.Anchored 3.Spuds	Emission Factor (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Average fuel rate (kg per day)	Fuel density (kg/gal)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Outside Operating Days	Inside Operating Days	Operating Hours (hrs/day)	Total Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Total Fuel Usage (gal)
Inter Array Cable																									
Cable Lay Vessel	-Main engines	2	1	3.02	5,791	Diesel	29,000	3.18	8	6	48	18,239	40%	8	0	0	0	0%	0	290	24	6,960	2,644,654	40%	2,662,893
	-Main engines	2		3.02	3,861	Diesel			8	6	48			8	0	0			0	290	24	6,960			
	-Aux Gen	1		2	1,333	Diesel			8	6	48			8	0	0			0	290	24	6,960			
528 x 106 x 38	-Emerg Gen	1		2	588	Diesel			0	0	0			0	0	0			0	0	-	0			
Burial Tool	-Cable Burial Tool	1	1	1	588	Diesel	1,402	3.18	0	0	0	0	0%	0	0	0	0	0%	0	290	24	6,960	127,878	62%	127,878
528 x 106 x 38																									
Multi-Purpose Service Vessel	-Main Engines	4	1	2	2,446	Diesel	7,000	3.18	8	6	48	4,403	19%	8	6	48	4,403	19%	0	290	24	6,960	638,365	19%	642,767
																						0			
292 x 76 x 18 (18)																									
Crew Transfer Vessel	-Main Engines	4	N/A	1	800	Diesel	6,000	3.18	8	6	48	3,774	48%	8	6	48	3,774	48%	0	290	24	6,960	547,170	48%	550,943
	-Main Generators	2		1	32	Diesel			8	6	48			8	6	48			0	290	24	6,960			
65 x 23 x 6 (6)																									
Pre-Lay Grapnel Run Vessel	-Main Engines	2	N/A	1	450	Diesel	4,000	3.18	2	6	12	629	98%	2	6	12	629	98%	0	85	24	2,040	106,918	98%	107,547
	-Main Generators	2		1	80	Diesel			2	6	12			2	6	12			0	85	24	2,040			
92 x 26 x 8.5																									
Pre-Lay Survey Vessel	-Main Engines	2	N/A	2	1,400	Diesel	5,000	3.18	2	6	12	786	46%	2	6	12	786	46%	0	50	24	1,200	78,616	46%	79,403
85 x 23 x 5 (5)																									
Post-Lay Survey Vessel	-Main Engines	2	1	3.02	5,791	Diesel	9,000	3.18	2	6	12	1,415	12%	2	6	12	1,415	12%	0	18	24	432	50,943	22%	52,358
	-Main Engines	2		3.02	3,861	Diesel			2	6	12			2	6	12			0	18	24	0			
	-Aux. Generator	1		2	1,333	Diesel			2	6	12			2	6	12			0	18	24	0			
528 x 106 x 38	-Emergency Generator	1		2	588	Diesel			0	0	0			0	0	0			0	0	-	0			

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Non-Transit)											Total Emissions (Transit inside OCS Boundary)										
	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	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
Inter Array Cable																						
Cable Lay Vessel 528 x 106 x 38	23.54	456.58	235.45	10.05	9.74	17.50	2.11	30,557	0.45	1.43	30,994	0.16	3.15	1.62	0.07	0.07	0.12	1.45E-02	211	3.10E-03	9.84E-03	214
Burial Tool 528 x 106 x 38	0.56	20.44	10.43	0.54	0.52	1.36E-02	0.06	1,439	0.19	0.04	1,456	0	0	0	0	0	0	0	0	0	0	0
Multi-Purpose Service Vessel 292 x 76 x 18 (18)	5.21	102.04	52.06	6.45	6.25	0.07	0.55	7,184	0.94	0.21	7,270	0.04	0.70	0.36	0.04	0.04	4.70E-04	3.81E-03	50	6.46E-03	1.44E-03	50
Crew Transfer Vessel 65 x 23 x 6 (6)	2.41	87.46	44.62	2.30	2.23	0.06	0.24	6,158	0.80	0.18	6,231	0.02	0.60	0.31	0.02	0.02	4.02E-04	1.67E-03	42	5.54E-03	1.23E-03	43
Pre-Lay Grapnel Run Vessel 92 x 26 x 8.5	0.47	17.09	8.72	0.45	0.44	1.14E-02	0.05	1,203	0.16	0.03	1,218	2.77E-03	0.10	0.05	2.65E-03	2.57E-03	6.71E-05	2.78E-04	7	9.23E-04	2.05E-04	7
Pre-Lay Survey Vessel 85 x 23 x 5 (5)	0.64	12.57	6.41	0.79	0.77	8.38E-03	0.07	885	0.12	0.03	895	6.41E-03	0.13	0.06	7.94E-03	7.70E-03	8.38E-05	6.81E-04	9	1.15E-03	2.56E-04	9
Post-Lay Survey Vessel 528 x 106 x 38	0.46	8.84	4.56	0.17	0.16	0.36	0.04	590	3.65E-03	0.03	598	1.26E-02	0.24	0.13	5.38E-03	5.21E-03	9.36E-03	1.13E-03	16	2.41E-04	7.63E-04	17

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Transit outside OCS Boundary)										
	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
Inter Array Cable											
Cable Lay Vessel 528 x 106 x 38	0	0	0	0	0	0	0	0	0	0	0
Burial Tool 528 x 106 x 38	0	0	0	0	0	0	0	0	0	0	0
Multi-Purpose Service Vessel 292 x 76 x 18 (18)	0.04	0.70	0.36	0.04	0.04	4.70E-04	3.81E-03	50	6.46E-03	1.44E-03	50
Crew Transfer Vessel 65 x 23 x 6 (6)	0.02	0.60	0.31	0.02	0.02	4.02E-04	1.67E-03	42	5.54E-03	1.23E-03	43
Pre-Lay Grapnel Run Vessel 92 x 26 x 8.5	2.77E-03	0.10	0.05	2.65E-03	2.57E-03	6.71E-05	2.78E-04	7	9.23E-04	2.05E-04	7
Pre-Lay Survey Vessel 85 x 23 x 5 (5)	6.41E-03	0.13	0.06	7.94E-03	7.70E-03	8.38E-05	6.81E-04	9	1.15E-03	2.56E-04	9
Post-Lay Survey Vessel 528 x 106 x 38	1.26E-02	0.24	0.13	5.38E-03	5.21E-03	9.36E-03	1.13E-03	16	2.41E-04	7.63E-04	17

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Vessel Data								Transit Data in OCS Boundary					Transit Data outside OCS Boundary					OCS Boundary		Non-Transit Data in OCS Boundary				OCS Boundary
	Engines / Equipment	No. of Engines	1. DP 2.Anchored 3.Spuds	Emission Factor (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Average fuel rate (kg per day)	Fuel density (kg/gal)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Outside Operating Days	Inside Operating Days	Operating Hours (hrs/day)	Total Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Total Fuel Usage (gal)
WTG Installation																									
Jack-up Vessel WTG installation 472 x 184 x 38	-Main Generators	6	3	3.03	6,434	Diesel	68,000	3.18	176	6	1,056	940,881	50%	176	6	1,056	940,881	50%	0	730	24	17,520	15,610,063	50%	16,550,943
	-Emergency Generator	1		4.01	1,800	Diesel			0	0	0			0	0	0			0	0	-	-			
Walk-to-Work Vessel Commissioning 354 x 52 x 31 (18)	-Main Generators	4	1	2	1,609	Diesel	10,000	3.18	176	6	1,056	138,365	35%	176	6	1,056	138,365	35%	0	730	24	17,520	2,295,597	35%	2,433,962
	-Aux. Generator	1		1	1,072	Diesel			176	6	1,056			176	6	1,056			0	730	24	17,520			
	-Emergency Generator	1		1	201	Diesel			0	0	0			0	0	0			0	0	-	-			
Tug 1 for WTG Barges 132 x 41 x 20 (18)	-Main Engines	2	N/A	2	3,634	Diesel	13,900	3.18	88	6	528	96,164	46%	88	6	528	96,164	46%	0	365	24	8,760	1,595,440	46%	1,691,604
	-Main Generators	2		1	288	Diesel			88	6	528			88	6	528			0	365	24	8,760			
	-Emergency Generator	1		1	133	Diesel			0	0	0			0	0	0			0	0	-	-			
Tug 2 for WTG Barges 132 x 41 x 20 (18)	-Main Engines	2	N/A	2	3,634	Diesel	13,900	3.18	88	6	528	96,164	46%	88	6	528	96,164	46%	0	365	24	8,760	1,595,440	46%	1,691,604
	-Main Generators	2		1	288	Diesel			88	6	528			88	6	528			0	365	24	8,760			
	-Emergency Generator	1		1	133	Diesel			0	0	0			0	0	0			0	0	-	-			
WTG Barge 1 & 2 400 x 100 x 20	Ballast Pumps	12	N/A	1	44	Diesel	338	3.18	0	0	0	0	0%	0	0	0	0	0%	0	730	4	2,920	77,591	100%	77,591
Assist Tugboat 112 x 35 x 19 (19)	-Main Engines	2	N/A	2	2,675	Diesel	11,700	3.18	176	6	1,056	161,887	53%	176	6	1,056	161,887	53%	0	730	24	17,520	2,685,849	53%	2,847,736
	-Aux. Generators	2		1	201	Diesel			176	6	1,056			176	6	1,056			0	730	24	17,520			
WTG Interarray Cable Termination Generators	Generators	10	N/A	254	20	Diesel	1,030	3.18	0	0	0	0	0%	0	0	0	0	0%	0	90	24	2,160	29,151	133%	29,151
Aux Vessels																									
Sandwave Dredging Vessel 480 x 92 x 36 (30)	-Tugboat Main Engines	2	N/A	3	7,831	Diesel	25,000	3.18	98	6	588	192,610	46%	98	6	588	192,610	46%	0	98	12	1,176	770,440	91%	963,050
	-Tugboat Harbor Generator	1		1	979	Diesel			0	0	0			0	0	0			0	0	-	-			
	-Tugboat Emergency Generator	1		1	737	Diesel			0	0	0			0	0	0			0	0	-	-			
Sandwave Dredging Vessel 480 x 92 x 36 (30)	-Dredger Pump Engines	2	N/A	3	5,000	Diesel	9,862	3.18	0	0	0	0	0%	0	0	0	0	0%	0	98	12	1,176	303,933	56%	303,933
	-Dredger Harbor Generator	1		2	1,220	Diesel			0	0	0			0	0	0			0	0	12	-			
Boulder Picking Vessel 1 146 x 46 x 25 (21)	-Main Engines	2	N/A	2	5,440	Diesel	10,000	3.18	14	6	84	11,006	24%	14	6	84	11,006	24%	0	98	24	2,352	308,176	24%	319,182
	-Harbor Generator	1		1	456	Diesel			0	0	0			0	0	0			0	0	-	-			
	-Emergency Generator	1		1	168	Diesel			0	0	0			0	0	0			0	0	-	-			
Boulder Picking Vessel 2 146 x 46 x 25 (21)	-Main Engines	2	N/A	2	5,440	Diesel	10,000	3.18	14	6	84	11,006	24%	14	6	84	11,006	24%	0	98	24	2,352	308,176	24%	319,182
	-Harbor Generator	1		1	456	Diesel			0	0	0			0	0	0			0	0	-	-			
	-Emergency Generator	1		1	168	Diesel			0	0	0			0	0	0			0	0	-	-			
Crossing Protection Vessel 146 x 46 x 25 (21)	-Main Engines	2	N/A	2	5,440	Diesel	10,000	3.18	19	6	114	14,937	24%	19	6	114	14,937	24%	0	131	24	3,144	411,950	24%	426,887
	-Harbor Generator	1		1	456	Diesel			0	0	0			0	0	0			0	0	-	-			
	-Emergency Generator	1		1	168	Diesel			0	0	0			0	0	0			0	0	-	-			
Boulder Ploughing Vessel 190 x 36 x 11 (11)	-Main Engines	2	N/A	2	1,920	Diesel	8,000	3.18	27	6	162	16,981	48%	27	6	162	16,981	48%	0	189	24	4,536	475,472	48%	492,453
	-Main Generators	2		1	228	Diesel			27	6	162			27	6	162			0	189	24	4,536			
Safety Vessel 65 x 17 x 5	-Main Engines	2	N/A	1	660	Diesel	5,000	3.18	111	6	666	43,632	95%	111	6	666	43,632	95%	0	1557	24	37,368	2,448,113	95%	2,491,745
	-Main Generators	2		1	27	Diesel			111	6	666			111	6	666			0	1557	24	37,368			

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Non-Transit)											Total Emissions (Transit inside OCS Boundary)										
	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	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
WTG Installation																						
Jack-up Vessel WTG installation 472 x 184 x 38	139.86	675.30	1,398.59	51.83	50.28	110.99	12.35	180,720	1.12	8.67	183,332	8.43	40.70	84.30	3.12	3.03	6.69	0.74	10,893	0.07	0.52	11,050
Walk-to-Work Vessel Commissioning 354 x 52 x 31 (18)	17.49	366.94	187.21	21.25	20.62	0.24	1.85	25,836	3.37	0.75	26,143	1.05	22.12	11.28	1.28	1.24	1.48E-02	0.11	1,557	0.20	0.05	1,576
Tug 1 for WTG Barges 132 x 41 x 20 (18)	12.57	255.02	130.11	15.42	14.96	0.17	1.33	17,956	2.34	0.52	18,169	0.76	15.37	7.84	0.93	0.90	1.03E-02	0.08	1,082	0.14	0.03	1,095
Tug 2 for WTG Barges 132 x 41 x 20 (18)	12.57	255.02	130.11	15.42	14.96	0.17	1.33	17,956	2.34	0.52	18,169	0.76	15.37	7.84	0.93	0.90	1.03E-02	0.08	1,082	0.14	0.03	1,095
WTG Barge 1 & 2 400 x 100 x 20	0.34	12.40	6.33	0.33	0.32	8.28E-03	0.03	873	0.11	0.03	884	0	0	0	0	0	0	0	0	0	0	0
Assist Tugboat 112 x 35 x 19 (19)	21.20	429.32	219.04	26.02	25.24	0.29	2.25	30,228	3.94	0.88	30,587	1.28	25.88	13.20	1.57	1.52	0.02	0.14	1,822	0.24	0.05	1,844
WTG Interarray Cable Termination Generators	0.19	6.61	0.52	0.09	0.08	0.20	0.02	328	1.90E-03	1.47E-02	333	0	0	0	0	0	0	0	0	0	0	0
Aux Vessels																						
Sandwave Dredging Vessel 480 x 92 x 36 (30)	6.90	182.23	15.19	2.56	2.48	5.48	0.61	8,919	0.06	0.43	9,048	1.73	45.56	3.80	0.64	0.62	1.37	0.15	2,230	1.38E-02	0.11	2,262
Sandwave Dredging Vessel 480 x 92 x 36 (30)	2.72	71.89	5.99	1.01	0.98	2.16	0.24	3,519	0.02	0.17	3,570	0	0	0	0	0	0	0	0	0	0	0
Boulder Picking Vessel 1 146 x 46 x 25 (21)	2.51	49.26	25.13	3.11	3.02	0.03	0.27	3,468	0.45	0.10	3,510	0.09	1.76	0.90	0.11	0.11	1.17E-03	9.53E-03	124	0.02	3.59E-03	125
Boulder Picking Vessel 2 146 x 46 x 25 (21)	2.51	49.26	25.13	3.11	3.02	0.03	0.27	3,468	0.45	0.10	3,510	0.09	1.76	0.90	0.11	0.11	1.17E-03	9.53E-03	124	0.02	3.59E-03	125
Crossing Protection Vessel 146 x 46 x 25 (21)	3.36	65.85	33.60	4.16	4.04	0.04	0.36	4,636	0.60	0.13	4,691	0.12	2.39	1.22	0.15	0.15	1.59E-03	1.29E-02	168	0.02	4.87E-03	170
Boulder Ploughing Vessel 190 x 36 x 11 (11)	3.69	76.00	38.78	4.50	4.37	0.05	0.39	5,351	0.70	0.16	5,415	0.13	2.71	1.38	0.16	0.16	1.81E-03	1.39E-02	191	0.02	5.54E-03	193
Safety Vessel 65 x 17 x 5	10.78	391.32	199.65	10.30	9.99	0.26	1.08	27,552	3.59	0.80	27,880	0.19	6.97	3.56	0.18	0.18	4.65E-03	0.02	491	0.06	1.42E-02	497

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Table N-2. Total Project Construction Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Transit outside OCS Boundary)										
	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
WTG Installation											
Jack-up Vessel WTG installation 472 x 184 x 38	8.43	40.70	84.30	3.12	3.03	6.69	0.74	10,893	0.07	0.52	11,050
Walk-to-Work Vessel Commissioning 354 x 52 x 31 (18)	1.05	22.12	11.28	1.28	1.24	1.48E-02	0.11	1,557	0.20	0.05	1,576
Tug 1 for WTG Barges 132 x 41 x 20 (18)	0.76	15.37	7.84	0.93	0.90	1.03E-02	0.08	1,082	0.14	0.03	1,095
Tug 2 for WTG Barges 132 x 41 x 20 (18)	0.76	15.37	7.84	0.93	0.90	1.03E-02	0.08	1,082	0.14	0.03	1,095
WTG Barge 1 & 2 400 x 100 x 20	0	0	0	0	0	0	0	0	0	0	0
Assist Tugboat 112 x 35 x 19 (19)	1.28	25.88	13.20	1.57	1.52	0.02	0.14	1,822	0.24	0.05	1,844
WTG Interarray Cable Termination Generators	0	0	0	0	0	0	0	0	0	0	0
Aux Vessels											
Sandwave Dredging Vessel 480 x 92 x 36 (30)	1.73	45.56	3.80	0.64	0.62	1.37	0.15	2,230	1.38E-02	0.11	2,262
Sandwave Dredging Vessel 480 x 92 x 36 (30)	0	0	0	0	0	0	0	0	0	0	0
Boulder Picking Vessel 1 146 x 46 x 25 (21)	0.09	1.76	0.90	0.11	0.11	1.17E-03	9.53E-03	124	0.02	3.59E-03	125
Boulder Picking Vessel 2 146 x 46 x 25 (21)	0.09	1.76	0.90	0.11	0.11	1.17E-03	9.53E-03	124	0.02	3.59E-03	125
Crossing Protection Vessel 146 x 46 x 25 (21)	0.12	2.39	1.22	0.15	0.15	1.59E-03	1.29E-02	168	0.02	4.87E-03	170
Boulder Ploughing Vessel 190 x 36 x 11 (11)	0.13	2.71	1.38	0.16	0.16	1.81E-03	1.39E-02	191	0.02	5.54E-03	193
Safety Vessel 65 x 17 x 5	0.19	6.97	3.56	0.18	0.18	4.65E-03	0.02	491	0.06	1.42E-02	497

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-2. Total Project Construction Emissions

Total Project Non-Transit Construction Emissions (tons)

VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
434.5	6,309.7	4,597.8	306.2	297.0	204.5	41.4	622,837	40.4	24.3	631,086

Total Project Transit Construction Emissions (tons)

VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
35.9	467.0	337.1	22.8	22.2	18.6	3.3	48,563	2.6	2.0	49,216

Total Project Construction Emissions (tons)

VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
470.4	6,776.7	4,934.9	329.0	319.2	223.1	44.7	671,399	43.0	26.3	680,303

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-3. Operating and Maintenance Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Vessel Data								Transit Data in OCS Boundary					Transit Data outside OCS Boundary					OCS Boundary		Non-Transit Data in OCS Boundary				OCS Boundary
	Engines / Equipment	No. of Engines	1. DP 2.Anchored 3.Spuds	Emission Factor (see EFs worksheet)	Engine Rating (hp)	Fuel Type	Average fuel rate (kg per day)	Fuel density (kg/gal)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Round Trips (RT)	Duration (hrs/RT)	Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Outside Operating Days	Inside Operating Days	Operating Hours (hrs/day)	Total Operating Hours (hrs)	Fuel Usage (gal)	Average load (%)	Total Fuel Usage (gal)
O&M																									
Service Operations Vessel	-Main Generators	2	1	2	2,466	Diesel	10,000	3.18	26	6	156	20,440	30%	26	6	156	20,440	30%	0	352	24	8,448	1,106,918	30%	1,127,358
	-Main Generators	2		2	1,850	Diesel			26	6	156			26	6	156			0	352	24	8,448			
	-Emergency Generator	1		1	382	Diesel			0	0	0			0	0	0			0	0	-	-			
243 x 56 x 26 (21)																									
Crew Transfer Vessel 1	-Main Engines	4	N/A	3.05	585	Diesel	4,000	3.18	26	6	156	8,176	43%	26	6	156	8,176	43%	0	352	12	4,224	442,767	85%	450,943
	-Aux. Generator	1		3.04	47	Diesel			26	6	156			26	6	156			0	352	12	4,224			
	-Aux. Engine	1		3.04	47	Diesel			26	6	156			26	6	156			0	352	12	4,224			
114 x 24 x 7																									
Crew Transfer Vessel 2	-Main Engines	4	N/A	3.05	585	Diesel	4,000	3.18	26	6	156	8,176	43%	26	6	156	8,176	43%	0	352	12	4,224	442,767	85%	450,943
	-Aux. Generator	1		3.04	47	Diesel			26	6	156			26	6	156			0	352	12	4,224			
	-Aux. Engine	1		3.04	47	Diesel			26	6	156			26	6	156			0	352	12	4,224			
114 x 24 x 7																									
Jack-up Vessel	-Main Generators	6	3	3.03	6,434	Diesel	68,000	3.18	2	6	12	10,692	50%	2	6	12	10,692	50%	0	30	24	720	641,509	50%	652,201
WTG Maintenance	-Emergency Generator	1		4.01	1,800	Diesel			0	0	0			0	0	0			0	0	24	-			
472 x 184 x 38																									
Survey Vessel	-Main Engines	2	N/A	2	1,400	Diesel	5,000	3.18	6	6	36	2,358	46%	6	6	36	2,358	46%	0	60	24	1,440	94,340	46%	96,698
85 x 23 x 5 (5)																									
Fall Pipe Vessel	-Main Generator	4	1	3.02	5,230	Diesel	26,500	3.18	4	6	24	8,333	34%	4	6	24	8,333	34%	0	30	24	720	250,000	34%	258,333
Scour protection (2024)	-Aux. Generator	1		2	1,332	Diesel			4	6	24			4	6	24			0	30	24	720			
507 x 106 x 25 (25)	-Emergency Generator	1		1	253	Diesel			0	0	0			0	0	0			0	0	-	-			
Cable Lay Vessel	-Main engines	2	1	3.02	5,791	Diesel	22,000	3.18	4	6	24	6,918	30%	4	6	24	6,918	30%	0	30	24	720	207,547	30%	214,465
	-Main engines	2		3.02	3,861	Diesel			4	6	24			4	6	24			0	30	24	720			
	-Aux Gen	1		2	1,333	Diesel			4	6	24			4	6	24			0	30	24	720			
528 x 106 x 38	-Emerg Gen	1		2	588	Diesel			0	0	0			0	0	0			0	0	-	-			

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-3. Operating and Maintenance Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Non-Transit)											Total Emissions (Transit inside OCS Boundary)										
	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	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
O&M																						
Service Operations Vessel 243 x 56 x 26 (21)	5.16 3.87 0	101.11 75.83 0	51.58 38.69 0	6.39 4.79 0	6.20 4.65 0	0.07 0.05 0	0.55 0.41 0	7,119 5,339 0	0.93 0.70 0	0.21 0.15 0	7,203 5,403 0	0.10 0.07 0	1.87 1.40 0	0.95 0.71 0	0.12 0.09 0	0.11 0.09 0	1.25E-03 9.34E-04 0	1.01E-02 7.59E-03 0	131 99 0	0.02 1.29E-02 0	3.81E-03 2.86E-03 0	133 100 0
Crew Transfer Vessel 1 114 x 24 x 7	1.32 0.03 0.03	37.56 0.63 0.63	34.71 0.70 0.70	0.69 0.04 0.04	0.67 0.04 0.04	0.05 9.12E-04 9.12E-04	0.12 3.00E-03 3.00E-03	4,791 96 96	0.62 1.26E-02 1.26E-02	0.14 2.79E-03 2.79E-03	4,848 97 97	0.02 4.89E-04 4.89E-04	0.69 1.16E-02 1.16E-02	0.64 1.29E-02 1.29E-02	1.28E-02 7.73E-04 7.73E-04	1.24E-02 7.49E-04 7.49E-04	8.38E-04 1.68E-05 1.68E-05	2.23E-03 5.54E-05 5.54E-05	88 1.78 1.78	1.15E-02 2.32E-04 2.32E-04	2.56E-03 5.15E-05 5.15E-05	90 1.80 1.80
Crew Transfer Vessel 2 114 x 24 x 7	1.32 0.03 0.03	37.56 0.63 0.63	34.71 0.70 0.70	0.69 0.04 0.04	0.67 0.04 0.04	0.05 9.12E-04 9.12E-04	0.12 3.00E-03 3.00E-03	4,791 96 96	0.62 1.26E-02 1.26E-02	0.14 2.79E-03 2.79E-03	4,848 97 97	0.02 4.89E-04 4.89E-04	0.69 1.16E-02 1.16E-02	0.64 1.29E-02 1.29E-02	1.28E-02 7.73E-04 7.73E-04	1.24E-02 7.49E-04 7.49E-04	8.38E-04 1.68E-05 1.68E-05	2.23E-03 5.54E-05 5.54E-05	88 1.78 1.78	1.15E-02 2.32E-04 2.32E-04	2.56E-03 5.15E-05 5.15E-05	90 1.80 1.80
Jack-up Vessel WTG Maintenance 472 x 184 x 38	5.75 0	27.75 0	57.48 0	2.13 0	2.07 0	4.56 0	0.51 0	7,427 0	0.05 0	0.36 0	7,534 0	0.10 0	0.46 0	0.96 0	0.04 0	0.03 0	0.08 0	8.46E-03 0	124 0	7.66E-04 0	5.94E-03 0	126 0
Survey Vessel 85 x 23 x 5 (5)	0.77	15.08	7.69	0.95	0.92	1.01E-02	0.08	1,062	0.14	0.03	1,074	0.02	0.38	0.19	0.02	0.02	2.52E-04	2.04E-03	27	3.46E-03	7.69E-04	27
Fall Pipe Vessel Scour protection (2024) 507 x 106 x 25 (25)	2.09 0.13 0	40.56 2.61 0	20.93 1.33 0	0.78 0.17 0	0.75 0.16 0	1.66 1.74E-03 0	0.18 1.42E-02 0	2,705 184 0	0.02 0.02 0	0.13 5.33E-03 0	2,744 186 0	0.07 4.44E-03 0	1.35 0.09 0	0.70 0.04 0	0.03 5.50E-03 0	0.03 5.34E-03 0	0.06 5.81E-05 0	6.16E-03 4.72E-04 0	90 6.13 0	5.58E-04 8.00E-04 0	4.33E-03 1.78E-04 0	91 6.21 0
Cable Lay Vessel 528 x 106 x 38	1.04 0.69 0.12 0	20.10 13.40 2.34 0	10.37 6.91 1.19 0	0.38 0.26 0.15 0	0.37 0.25 0.14 0	0.82 0.55 1.56E-03 0	0.09 0.06 1.27E-02 0	1,340 893 165 0	8.30E-03 5.53E-03 0.02 0	0.06 0.04 4.77E-03 0	1,359 906 167 0	0.03 0.02 3.98E-03 0	0.67 0.45 0.08 0	0.35 0.23 0.04 0	1.28E-02 8.54E-03 4.93E-03 0	1.24E-02 8.28E-03 4.78E-03 0	0.03 1.83E-02 5.20E-05 0	3.05E-03 2.04E-03 4.23E-04 0	45 30 5.49 0	2.77E-04 1.84E-04 7.16E-04 0	2.14E-03 1.43E-03 1.59E-04 0	45 30 5.56 0

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-3. Operating and Maintenance Emissions

Vessel Purpose Vessel Dimensions (ft) L x W x D (Draft)	Total Emissions (Transit outside OCS Boundary)										
	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
O&M											
Service Operations Vessel 243 x 56 x 26 (21)	0.10 0.07 0	1.87 1.40 0	0.95 0.71 0	0.12 0.09 0	0.11 0.09 0	1.25E-03 9.34E-04 0	1.01E-02 7.59E-03 0	131 99 0	0.02 1.29E-02 0	3.81E-03 2.86E-03 0	133 100 0
Crew Transfer Vessel 1 114 x 24 x 7	0.02 4.89E-04 4.89E-04	0.69 1.16E-02 1.16E-02	0.64 1.29E-02 1.29E-02	1.28E-02 7.73E-04 7.73E-04	1.24E-02 7.49E-04 7.49E-04	8.38E-04 1.68E-05 1.68E-05	2.23E-03 5.54E-05 5.54E-05	88 1.78 1.78	1.15E-02 2.32E-04 2.32E-04	2.56E-03 5.15E-05 5.15E-05	90 1.80 1.80
Crew Transfer Vessel 2 114 x 24 x 7	0.02 4.89E-04 4.89E-04	0.69 1.16E-02 1.16E-02	0.64 1.29E-02 1.29E-02	1.28E-02 7.73E-04 7.73E-04	1.24E-02 7.49E-04 7.49E-04	8.38E-04 1.68E-05 1.68E-05	2.23E-03 5.54E-05 5.54E-05	88 1.78 1.78	1.15E-02 2.32E-04 2.32E-04	2.56E-03 5.15E-05 5.15E-05	90 1.80 1.80
Jack-up Vessel WTG Maintenance 472 x 184 x 38	0.10 0 0.00	0.46 0 0.00	0.96 0 0.00	0.04 0 0.00	0.03 0 0.00	0.08 0 0.00	8.46E-03 0 0.00	124 0 0	7.66E-04 0 0.00	5.94E-03 0 0.00	126 0 0
Survey Vessel 85 x 23 x 5 (5)	0.02	0.38	0.19	0.02	0.02	2.52E-04	2.04E-03	27	3.46E-03	7.69E-04	27
Fall Pipe Vessel Scour protection (2024) 507 x 106 x 25 (25)	0.07 4.44E-03 0	1.35 0.09 0	0.70 0.04 0	0.03 5.50E-03 0	0.03 5.34E-03 0	0.06 5.81E-05 0	6.16E-03 4.72E-04 0	90 6.13 0	5.58E-04 8.00E-04 0	4.33E-03 1.78E-04 0	91 6.21 0
Cable Lay Vessel 528 x 106 x 38	0.03 0.02 3.98E-03 0	0.67 0.45 0.08 0	0.35 0.23 0.04 0	1.28E-02 8.54E-03 4.93E-03 0	1.24E-02 8.28E-03 4.78E-03 0	0.03 1.83E-02 5.20E-05 0	3.05E-03 2.04E-03 4.23E-04 0	45 30 5.49 0	2.77E-04 1.84E-04 7.16E-04 0	2.14E-03 1.43E-03 1.59E-04 0	45 30 5.56 0

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Table N-3. Operating and Maintenance Emissions

O&M Non-Transit Emissions (tons)

VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
22.4	376.4	268.4	17.5	17.0	7.8	2.2	36,199.5	3.2	1.3	36,661.9

O&M Transit Emissions (tons)

VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
0.9	16.3	11.0	0.7	0.7	0.4	0.1	1,481.3	0.1	0.1	1,500.4

O&M Total Emissions (tons)

VOC	NO_X	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e
23.3	392.8	279.4	18.3	17.7	8.2	2.3	37,680.8	3.3	1.3	38,162.2

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS
Notes on Marine Vessel Emissions

1. Construction and O&M emissions were estimated based on the number of transits and operating days provided by the project.
2. Transit emissions are based on an assumed vessel speed of 10 knots for all vessel types, when traveling within 25 nm of the OCS source.
3. 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.
4. Default 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.
5. For Category 1 and 2 engines known to meet EPA Tier 3 or 4 standards, the corresponding emission factors from Tables 1, 2, or 3 to 40 CFR § 1042.101 were used. Where EPA has not established Tier 3 or 4 emission standards for CO, the default factors from the ICF report were substituted.
6. For Category 3 engines known to meet either EPA Tier 1, 2, or 3, the corresponding emission factors from 40 CFR § 1042.104 were used for NOx and CO. Where EPA has not established Category 3 emission standards for CO and PM, the default factors from the ICF report were substituted. VOC emissions for Category 3 engines are also based on the default ICF factor, in lieu of the EPA Category 3 HC standard.
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

Table N-4. 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%	38	158,372	0.24	8.81	0.88	0.18	0.17	1.25E-02	0.06	1,782.38	1.48E-02	0.05	1,796.28
All-Terrain Forklift	2270002057	150	diesel	113	8	59%	57	44,549	0.04	0.51	0.18	0.04	0.04	3.44E-03	1.02E-02	501.37	3.18E-03	1.28E-02	505.26
Front End Loader	2270002060	200	diesel	114	8	59%	28	29,181	0.02	0.19	0.07	1.48E-02	1.44E-02	2.22E-03	3.95E-03	328.41	1.14E-03	8.36E-03	330.93
Medium Crane	2270002045	400	diesel	112	8	43%	38	57,091	0.08	1.56	0.38	0.06	0.06	4.69E-03	0.02	642.53	5.05E-03	0.02	647.53
Medium Aerial Lift	2270003010	20	diesel	116	8	21%	38	1,820	0.03	0.14	0.11	1.49E-02	1.45E-02	1.88E-04	7.00E-03	20.49	9.91E-04	5.22E-04	20.67
Medium Excavator	2270002036	200	diesel	111	8	59%	47	48,985	1.48E-02	0.20	0.05	1.32E-02	1.28E-02	3.66E-03	3.56E-03	551.30	9.52E-04	1.40E-02	555.51
Piling Rig	2270002033	200	diesel	110	8	43%	9	6,751	0.05	0.60	0.13	0.03	0.03	6.75E-04	1.13E-02	75.98	2.44E-03	1.93E-03	76.62
Generator	2270006005	150	diesel	117	8	43%	57	32,091	0.13	1.60	0.46	0.10	0.10	2.79E-03	0.03	361.17	5.18E-03	9.20E-03	364.04
SWITCHING STATION																				
Large Bulldozer	2270002069	800	diesel	105	8	59%	55	229,222	0.35	12.74	1.27	0.26	0.25	0.02	0.09	2,579.76	0.02	0.07	2,599.88
All-Terrain Forklift	2270002057	150	diesel	103	8	59%	83	64,869	0.06	0.75	0.27	0.06	0.06	5.00E-03	1.48E-02	730.07	4.63E-03	0.02	735.72
Front End Loader	2270002060	200	diesel	104	8	59%	41	42,729	0.02	0.28	0.10	0.02	0.02	3.25E-03	5.78E-03	480.89	1.66E-03	1.22E-02	484.58
Medium Crane	2270002045	400	diesel	102	8	43%	55	82,632	0.12	2.26	0.55	0.09	0.09	6.78E-03	0.03	929.98	7.31E-03	0.02	937.22
Medium Aerial Lift	2270003010	20	diesel	106	8	21%	55	2,635	0.04	0.20	0.16	0.02	0.02	2.73E-04	1.01E-02	29.65	1.43E-03	7.55E-04	29.91
Medium Excavator	2270002036	200	diesel	101	8	59%	74	77,126	0.02	0.31	0.08	0.02	0.02	5.77E-03	5.60E-03	868.01	1.50E-03	0.02	874.63
Piling Rig	2270002033	200	diesel	100	8	43%	14	10,502	0.07	0.93	0.20	0.04	0.04	1.05E-03	0.02	118.19	3.80E-03	3.01E-03	119.19
Generator	2270006005	150	diesel	107	8	43%	83	46,730	0.19	2.32	0.67	0.15	0.14	4.06E-03	0.05	525.91	7.54E-03	1.34E-02	530.09
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%	675	506,351	3.52	44.85	9.80	2.13	2.07	0.05	0.85	5,698.68	0.18	0.15	5,746.51
Onshore Cable Route Compressor	2270006015	150	diesel	108	8	43%	675	380,329	0.41	7.14	1.69	0.43	0.41	0.03	0.10	4,280.38	0.03	0.11	4,313.69
Onshore Cable Route Excavator	2270002036	200	diesel	101	8	59%	675	703,514	0.21	2.87	0.77	0.19	0.18	0.05	0.05	7,917.63	0.01	0.20	7,978.06
Onshore Cable Route Tractor	2270002075	450	diesel	105.1	8	59%	675	1,582,681	1.38	24.87	9.05	1.38	1.34	0.12	0.33	17,812.14	0.09	0.45	17,949.65
INTERCONNECTION CABLE																				
Large Bulldozer	2270002069	800	diesel	105	8	59%	14	58,348	0.09	3.24	0.32	0.07	0.06	4.59E-03	0.02	656.67	5.46E-03	0.02	661.79
All-Terrain Forklift	2270002057	150	diesel	103	8	59%	14	10,942	1.04E-02	0.13	0.05	9.94E-03	9.64E-03	8.44E-04	2.50E-03	123.14	7.81E-04	3.14E-03	124.10
Front End Loader	2270002060	200	diesel	104	8	59%	14	14,590	8.20E-03	0.10	0.03	7.42E-03	7.20E-03	1.11E-03	1.97E-03	164.21	5.68E-04	4.18E-03	165.47
Medium Crane	2270002045	400	diesel	102	8	43%	14	21,034	0.03	0.57	0.14	0.02	0.02	1.73E-03	7.14E-03	236.72	1.86E-03	6.03E-03	238.56
Medium Aerial Lift	2270003010	20	diesel	106	8	21%	14	671	1.07E-02	0.05	0.04	5.49E-03	5.33E-03	6.94E-05	2.58E-03	7.55	3.65E-04	1.92E-04	7.61
Medium Excavator	2270002036	200	diesel	101	8	59%	14	14,591	4.40E-03	0.06	0.02	3.92E-03	3.80E-03	1.09E-03	1.06E-03	164.22	2.84E-04	4.18E-03	165.47
Piling Rig	2270002033	200	diesel	100	8	43%	14	10,502	0.07	0.93	0.20	0.04	0.04	1.05E-03	0.02	118.19	3.80E-03	3.01E-03	119.19
Generator	2270006005	150	diesel	107	8	43%	14	7,882	0.03	0.39	0.11	0.02	0.02	6.84E-04	7.82E-03	88.71	1.27E-03	2.26E-03	89.41
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	**4,333,707**	**7.53**	**121.30**	**29.40**	**5.52**	**5.36**	**0.35**	**1.79**	**48,768.70**	**0.48**	**1.23**	**49,148.38**

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 26.9 acres (11.7 acres existing, plus 15.2 acre expansion).
9. Footprint for onshore switching station is assumed to be 45.4 acres (including temporary workspace).
10. Footprint for onshore cable landing is assumed to be 11.1 acres (disturbance of 2.83 acres).
11. Length of onshore export cable is assumed to be 4.4 miles.
12. Length of onshore interconnection cable is assumed to be 14.2 miles.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-5. 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, 200

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-6. 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, 200

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-7. OSS Generator Emissions

Generator Engine Data

Generator Manufacturer	Cummins	
Model	QSX15-G17	
Engine Type	Compression Ignition	
Rated engine output	kW	563
Rated engine output	bhp	755
Engine speed	rpm	1800
Fuel consumption at 100% load	gal/hr	35.3
Number of generators	engines	3
Annual operating hours per generator - Construction	hr/yr	7,320
Annual Fuel Usage per generator - Construction	gal/yr	258,396
Annual operating hours per generator - O&M	hr/yr	500
Annual Fuel Usage per generator - O&M	gal/yr	17,650

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)	4.78

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)	0.83
CO	lb/hr (per engine)	4.34
VOC	lb/hr (per engine)	0.24
PM10	lb/hr (per engine)	0.04
PM2.5	lb/hr (per engine)	0.04
SO2	lb/hr (per engine)	7.42E-03
HAP	lb/hr (per engine)	7.61E-03
CO2	lb/hr (per engine)	779.8
CH4	lb/hr (per engine)	3.16E-02
N2O	lb/hr (per engine)	6.33E-03
CO2e	lb/hr (per engine)	782.4

	Short Term Emissions (lb/hr per engine)	Annual Emissions Construction (tons/yr all 3 engines)	Annual Emissions O&M (tons/yr all 3 engines)
NOx	0.83	9.13	0.62
CO	4.34	47.70	3.26
VOC	0.24	2.59	0.18
PM10	0.04	0.41	0.03
PM2.5	0.04	0.40	0.03
SO2	7.42E-03	8.15E-02	5.57E-03
HAP	7.61E-03	8.36E-02	5.71E-03
CO2	779.8	8,562	585
CH4	0.03	0.35	0.02
N2O	6.33E-03	6.95E-02	4.74E-03
CO2e	782.4	8,591	587

Notes:

1. Engine power rating and fuel comsumption are based on vendor data.
2. It is assumed that each engine may be used for both emergency and non-emergency purposes. During commissioning, the engines will operate as non-emergency engines and are expected to potentially run for 7,320 consecutive hours. During O&M, these engines will only be used and operated as emergency engines, and are assumed to operate for 500 hours per year for the purpose of calculating potential emissions.
3. Emission factors for NOx, CO, VOC, and PM are based on EPA Tier 4 standards from Table 1 of 40 CFR 1039.101 (generator sets > 560 kW).
4. All particulate (PM) is assumed to be ≤ to 10 µm (PM10) and 97% of the PM is assumed to be smaller than 2.5 µm (PM2.5) based on US EPA Report Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition, No. NR-0009d, July 2010.
5. SO2 emission factor calculated from mass balance for 0.0015% by weight ULSD, assuming 100% conversion of fuel sulfur to SO2.
6. 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.
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

Table N-8. 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
Table N-9. 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
Table N-10. 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
Table N-11. 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

Table N-12. 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

Table N-13. 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} /d, /e	$PM_{2.5}$ /d	SO_2 /f	CO_2	CH_4	N_2O	(gal/hp-hr) /g
1	ICF Default Factors - 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	ICF Default Factors - Category 2 engines	0.37	7.3	3.73	0.46	0.45	0.0049	515	0.067	0.015	0.050
3	ICF Default Factors - 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
3.01	EPA Tier 1 - Cat 3 (model year 2004-2010) /b	0.37	9.0	0.82	0.14	0.13	0.296	482	0.003	0.023	0.046
3.02	EPA Tier 2 - Cat 3 (model year 2011-2015) /b	0.37	7.2	3.73	0.14	0.13	0.296	482	0.003	0.023	0.046
3.03	EPA Tier 3 - Cat 3 (model year 2016-later) /b	0.37	1.8	3.73	0.14	0.13	0.296	482	0.003	0.023	0.046
3.04	EPA Tier 3 - Cat 1 < 3700 kW (disp < 0.9; 19 ≤ kW < 75, 2014+)	0.14	3.4	3.73	0.22	0.22	0.0049	515	0.067	0.015	0.050
3.05	EPA Tier 3 - Cat 1 < 3700 kW (kW/L ≤ 35; 1.2 ≤ disp < 2.5; kW < 600; 2018+	0.14	4.0	3.73	0.07	0.07	0.0049	515	0.067	0.015	0.050
4.01	EPA Tier 4 - Cat 1/Cat 2 > 600 kW (600 ≤ kW < 1400) /c	0.14	1.34	3.73	0.03	0.03	0.0049	515	0.067	0.015	0.050
4.02	EPA Tier 4 - Cat 1/Cat 2 > 600 kW (1400 ≤ kW < 2000) /c	0.14	1.34	3.73	0.03	0.03	0.0049	515	0.067	0.015	0.050
4.03	EPA Tier 4 - Cat 1/Cat 2 > 600 kW (2000 ≤ kW ≤ 3700) /c	0.14	1.34	3.73	0.03	0.03	0.0049	515	0.067	0.015	0.050
4.04	EPA Tier 4 - Cat 1/Cat 2 > 600 kW (disp. < 15; kW > 3700; 2014-2015) /c	0.14	1.34	3.73	0.09	0.09	0.0049	515	0.067	0.015	0.050
4.05	EPA Tier 4 - Cat 1/Cat 2 > 600 kW (15 ≤ disp. < 30; kW > 3700; 2014-2015)	0.14	1.34	3.73	0.19	0.18	0.0049	515	0.067	0.015	0.050
4.06	EPA Tier 4 - Cat 1/Cat 2 > 600 kW (all disp; kW > 3700; 2016+) /c	0.14	1.34	3.73	0.04	0.04	0.0049	515	0.067	0.015	0.050
5	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 Default emission factors for Category 1, 2, and 3 engines are 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). Category 1 and 2 factors are from Table 3-8 , and Category 3 factors are from Tables 2-9, 2-13, and 2-16. Category 1 and 2 engines to be used for CVOWC are assumed to meet EPA Tier 1 and 2 marine engine standards respectively (providing conservative estimates for Category 1 engines); therefore the Tier 1 and 2 emission factors in Table 3-8 from the ICF International report were used.

/b For Category 3 engines known to meet either EPA Tier 1, 2, or 3, the corresponding emission factors from 40 CFR § 1042.104 were used for NOx and CO. Where EPA has not established Category 3 emission standards for CO and PM, the default factors from the ICF report were substituted. VOC emissions for Category 3 engines are also based on the default ICF factor, in lieu of the EPA Category 3 HC standard.

/c For Category 1 and 2 engines known to meet EPA Tier 3 or 4 standards, the corresponding emission factors from Tables 1, 2, or 3 to 40 CFR § 1042.101 were used. Where EPA has not established Tier 3 or 4 emission standards for CO, the default factors from the ICF report were substituted.

/d 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.

/e 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.

/f 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).

/g 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.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-13. Emission Factors

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

	NONROAD Source Category			NONROAD Emission Factors (g/hp-hr) /a								Climate Leaders (g/kWh) /b		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	Fuel Consumption gal/hp-hr /c	Default Load Factor
	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.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-13. Emission Factors

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

	NONROAD Source Category			NONROAD Emission Factors (g/hp-hr) /a								Climate Leaders (g/kWh) /b		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	Fuel Consumption gal/hp-hr /c	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.

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT - OCS AIR EMISSION CALCULATIONS

Table N-13. Emission Factors

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 - OCS AIR EMISSION CALCULATIONS

Table N-13. Emission Factors

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

			Subpart IIII standards (g/kWh) /a				(g/kWh) /b	Other Emission Factors (lb/MMBtu) /c, /d				Fuel Cons.
	Stationary Source Category	Engine Size (kW)	VOC	NO_x	CO	PM/ PM_{10}	$PM_{2.5}$	SO_2	CO_2	CH_4	N_2O	(gal/kWh) /e
254	Non-Emergency Engines Subject to Tier 4 Standards (2015 model year and later)	kW < 19	0.93	6.57	6.6	0.40	0.39	0.0015	163.1	0.007	0.001	0.067
255		19 <= kW < 56	0.58	4.12	5.0	0.03	0.03	0.0015	163.1	0.007	0.001	0.067
256		56 <= kW < 130	0.19	0.40	5.0	0.02	0.02	0.0015	163.1	0.007	0.001	0.067
257		130 <= kW <= 560	0.19	0.4	3.5	0.02	0.02	0.0015	163.1	0.007	0.001	0.067
258	Gensets	kW > 560	0.19	0.67	3.5	0.03	0.03	0.0015	163.1	0.007	0.001	0.067
259	All except gensets		0.19	3.5	3.5	0.04	0.04	0.0015	163.1	0.007	0.001	0.067

/a Values are from Table 1 of 40 CFR 1039.101, except as follows:
For highlighted cells, a combined standard was provided (NMHC+NOx). Values for NMHC+NOx were apportioned into NOx and VOC rates based on the ratio of Tier 1 limits (9.2 g/kWh NOx and 1.3 g/kWh HC).

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

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

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

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

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT

Table N-14. 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
Table N-15. EPA NEI HAP emission factors for Commercial Marine Vessels

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

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

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

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

COASTAL VIRGINIA OFFSHORE WIND COMMERCIAL PROJECT
Table N-16. HAP Emission Factors for 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
Table N-17. HAP Emission Factors for Large 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

Table N-18. HAP Emission Factors for 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

Table N-19. 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.