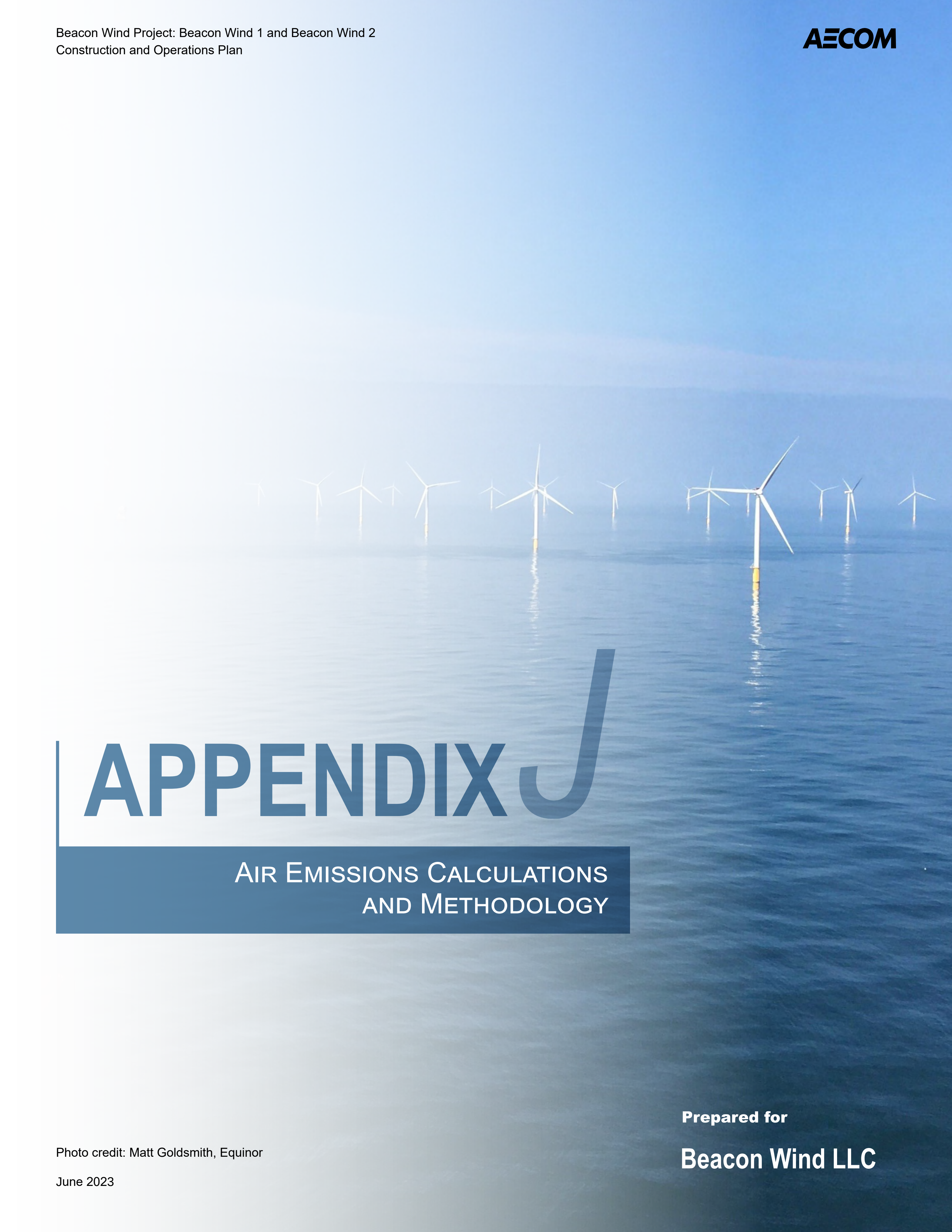
AECOM



APPENDIX J

Air Emissions Calculations and Methodology

Prepared for

Beacon Wind LLC

Photo credit: Matt Goldsmith, Equinor

June 2023

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Abbreviations and Acronyms

Acronym	Definition
ac	acres
AGRE	Astoria Gateway for Renewable Energy
AQCR	Air Quality Control Region
AR5	Fifth Assessment Report
AVERT	Avoided Emissions and Generation Tool
BACT	Best Available Control Technology
BOEM	Bureau of Ocean Energy Management
Btu/gal	British thermal units per gallon
BW1	Beacon Wind 1
BW2	Beacon Wind 2
CAA	Clean Air Act
CFR	Code of Federal Regulations
CH_4	methane
CMR	Code of Massachusetts Regulations
CMV	commercial marine vessel
COA	Corresponding Onshore Area
CO	carbon monoxide
CO_2	carbon dioxide
CO_{2e}	carbon dioxide equivalent
COP	Construction and Operations Plan
DP	dynamic positioning
EGU	electric generating units
EPA	United States Environmental Protection Agency
g	gram
gal/hr	gallons per hour
g/gal	gram per gallon
GHG	greenhouse gas
g/hp-hr	grams per horsepower hour
g/kWh	grams per kilowatt hour
g/lb	grams per pound
g/VMT	grams per vehicle mile traveled
GWP	global warming potential
ha	hectares
HAP	Hazardous Air Pollutants
HC	hydrocarbon
HDD	Horizontal Directional Drilling
hr.	hour
IPCC	Intergovernmental Panel on Climate Change
kg	kilogram
kg/gal	kilogram per gallon
kg/MMBtu	kilogram per million British thermal units
km	kilometers

Abbreviations and Acronyms	
Acronym	**Definition**
kW	kilowatt
LAER	Lowest Achievable Emission Rate
lb	pound
lb/hr	pounds per hour
lb/kg	pound per kilogram
lb/ton	pounds per ton
lb/MMBtu	pounds per million British thermal units
lb/MWh	pounds per megawatt hour
Lease Area	BOEM-designated Renewable Energy Lease Area OCS-A 0520
MassDEP	Massachusetts Department of Environmental Protection
MDO	marine diesel oil
MGO	marine gas oil
mi	miles
MMBtu	million British thermal units
MMBtu/hr	million British thermal units per hour
MOVES3	EPA's Motor Vehicle Emission Simulator
MSD	medium-speed diesel
MW	megawatts
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
nm	nautical miles
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
NY ISO	New York Independent System Operator
NYPA	New York Power Authority
NYSERDA	New York State Energy Research and Development Authority
OCS	Outer Continental Shelf
Pb	lead
PDE	Project Design Envelope
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
POI	Point of Interconnection
ppm	parts per million
SBMT	South Brooklyn Marine Terminal
SF_6	Sulfur hexafluoride
SO_2	sulfur dioxide
SOV	Service Operation Vessel
U.S.	United States
U.S.C.	United States Code
VOC	volatile organic compound

Appendix J Air Emissions Calculations and Methodology

J.1 Introduction

Beacon Wind LLC (Beacon Wind) proposes to construct and operate an offshore wind facility located in the designated Renewable Energy Lease Area OCS-A 0520 (Lease Area). The Lease Area covers approximately 128,811 acres (ac; 52,128 hectares [ha]) and is located approximately 20 statute miles (mi) (17 nautical miles [nm], 32 kilometers [km]) south of Nantucket, Massachusetts and 60 mi (52 nm, 97 km) east of Montauk, New York (**Figure J.1-1**).

Beacon Wind proposes to develop the entire Lease Area in two wind farms, known as Beacon Wind 1 (BW1) and Beacon Wind 2 (BW2) (collectively referred to hereafter as the Project). The individual wind farms within the Lease Area will be electrically isolated and independent from the other via transmission systems that connect two separate offshore substations to two onshore Points of Interconnection (POIs). However, if BW1 and BW2 both interconnect with the New York Independent System Operator (NY ISO), the Project will assess the possibility of cable linkage between BW1 and BW2. Each wind farm will gather the power from the associated turbines to a central offshore substation facility and deliver the generated power via a submarine export cable to an onshore substation facility for final delivery into the local utility distribution system at the selected POI. The purpose of the Project is to generate renewable electricity from an offshore wind farm(s) located in the Lease Area. The Project addresses the need identified by northeast states to achieve offshore wind goals: New York (9,000 megawatts [MW]), Connecticut (2,000 MW), Rhode Island (up to 1,000 MW), and Massachusetts (5,600 MW).

BW1 will be developed first and constitutes the northern portion of the Lease Area. It covers approximately 56,535 ac (22,879 ha). The BW1 wind farm has a 25-year offtake agreement with the New York State Energy Research and Development Authority (NYSERDA) to deliver the power to its identified POI in Queens, New York.

BW2 spans the southern portion of the Lease Area and will be developed after BW1. It covers approximately 51,611 ac (20,886 ha). Beacon Wind is considering an Overlap Area of 20,665 ac (8,363 ha) that may be included in either wind farm. BW2 is being developed to addresses the need for renewable energy identified by states across the region, including New York, Massachusetts, Rhode Island, and Connecticut. The interconnectedness of the New England transmission system, managed by the New England ISO (ISO-NE), allows a single point of interconnection in the region to deliver offshore wind energy to all of the New England states (Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine). The magnitude of regional targets for offshore wind and the limited amount of developable area, given current and reasonably foreseeable BOEM leasing activity, demonstrates a need for full-build out of the Lease Area.

BW2 plans to deliver power to identified POIs either in Waterford, Connecticut or Queens, New York. Two locations are under consideration in Queens, New York for the single proposed BW1 landfall and onshore substation facility. These locations include the New York Power Authority (NYPA) site in the northeastern corner of the Astoria power complex and the Astoria Gateway for Renewable Energy (AGRE) site (which includes AGRE East and AGRE West) situated centrally and on the northern end of the complex adjacent to the East River, both collectively referred to hereafter as NYPA and AGRE .

The Queens, New York, onshore substation facility sites that are not used (NYPA, AGRE East, or AGRE West) for BW1 will remain under consideration, in addition to the Waterford, Connecticut, site, for the single proposed BW2 onshore substation facility.

For the purposes of emission estimations, the number of wind turbines included under BW1 is 82, the count associated with the 2020 bid value, and the number of wind turbines included under BW2 is 73.

This report describes the methodology applied to calculate the anticipated air emissions associated with construction, operation and maintenance, and decommissioning of BW1 and BW2 as well as the results of the emissions calculations, which are detailed in this **Appendix J Air Emissions Calculations and Methodology**. Vessel specifications and durations have been selected to represent a maximum design scenario with respect to the potential emissions associated with construction and operation of BW1 and BW2. Actual vessels to be employed during construction and operation activities are subject to change.

There are seven primary categories of sources for which emissions were calculated:

- Commercial marine vessels (CMVs);
- Helicopters;
- Stationary diesel generator engines;
- Gas-insulated switchgear;
- Nonroad engines;
- On-road vehicles; and
- Fugitive emissions/construction dust.

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

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

- Other regulated precursor pollutants include:
  - Volatile organic compounds (VOC); and
  - Oxides of nitrogen (NO_X).

VOC and NO_X are the precursors and measured pollutants for the criteria pollutant ozone. NO_X and SO_2 are precursors for $PM_{2.5}$; SO_2 is also directly emitted, and a criteria pollutant identified above.

- HAPs cover a broad range of chemicals, which include but are not limited to:
  - Formaldehyde;
  - Acetaldehyde;
  - Benzene;
  - Naphthalene;
  - Acrolein;
  - 1,3-Butadiene;
  - Ethylbenzene; and
  - Polycyclic Organic Matter

- GHGs also include a range of chemical compounds but the Project will likely emit the following GHGs:
  - Carbon dioxide (CO_2);
  - Methane (CH_4);
  - Nitrous oxide (N_2O); and
  - Sulfur hexafluoride (SF_6).

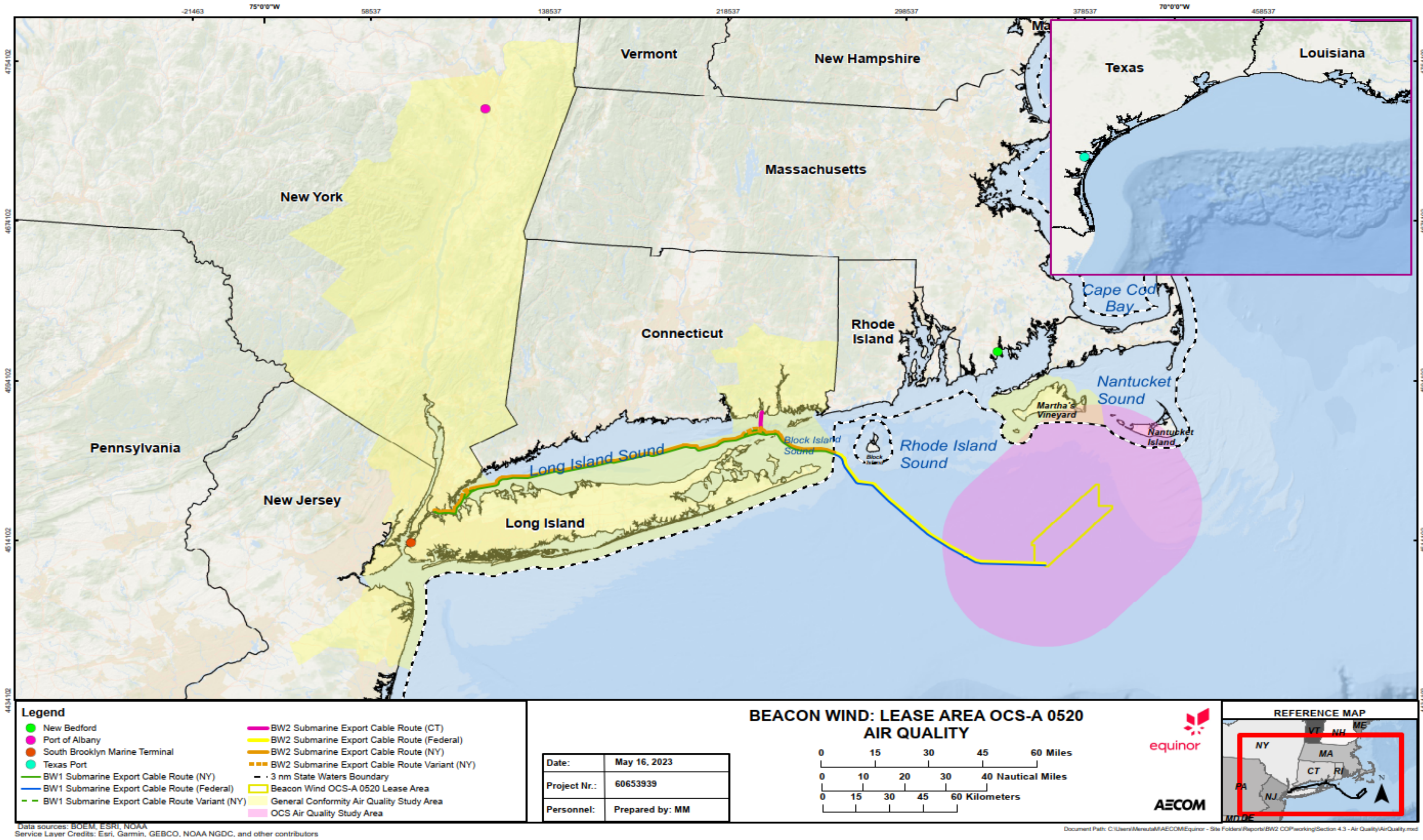
BW1 and BW2 combined emissions are summarized for three different permitting or regulatory applicability and compliance demonstrations:

- **Emissions 25 mi (21.7 nm, 40.2 km) from the source:** Emissions 25 mi (21.7 nm, 40.2 km) around the Outer Continental Shelf (OCS) source have been included as a screening for the Clean Air Permit requirements. A specific subsection of air emissions are regulated through the United States Environmental Protection Agency's (EPA) OCS air permit process. EPA has promulgated OCS air regulations at 40 Code of Federal Regulations (CFR) Part 55, which establish air pollution control and permitting requirements for emission sources and activities occurring on the OCS. According to Section 328 of the Clean Air Act (CAA) (42 United States Code [U.S.C.] § 7627(a)(4)(c)), an OCS source includes the following: (i) any equipment, activity, or facility that emits, or has the potential to emit, any air pollutant; (ii) is regulated or authorized under the OCS Lands Act (43 U.S.C. § 1331); and (iii) is located on the OCS or in or on waters above the OCS. This includes vessels that are permanently or temporarily attached to the seabed (40 CFR § 55.2).
- In addition to the federal OCS air regulations, the OCS sources operating within 25 mi (21.7 nm, 40.2 km) of the seaward boundary of a state are subject to the requirements applicable to the Corresponding Onshore Area (COA), as determined by EPA. For the Project, the COA is Massachusetts, in which case the OCS sources associated with the Project activities are expected to be subject to the air permitting requirements of the Massachusetts Department of Environmental Protection (MassDEP). This encompasses applicable Massachusetts air quality regulations, which include Best Available Control Technology (BACT) and Lowest Achievable Emission Rate (LAER) under 310 Code of Massachusetts Regulations (CMR) 7.00.
- In support of the Project's OCS air permit application, Beacon Wind developed an inventory of anticipated emissions from Project-related construction, operations and maintenance, and decommissioning vessels operating at or within 25 mi (21.7 nm, 40.2 km) of the Lease Area.

This inventory is meant as an emissions estimate for applicability but will be further refined in order to meet the requirements of 40 CFR Part 55 upon submittal of an application to EPA.

- **General Conformity Emissions:** The General Conformity rule requires federal agencies to demonstrate proposed actions comply with the National Ambient Air Quality Standards (NAAQS) (EPA 2020). Section 176I(1) of the CAA defines conformity as the upholding of “an implementation plan’s purpose of eliminating or reducing the severity and number of violations of the NAAQS and achieving expeditious attainment of such standards.” Therefore, in nonattainment or maintenance areas, federal agencies must demonstrate that the proposed actions conform to the applicable EPA-approved state implementation plan to achieve and/or maintain the NAAQS (EPA 2020). This is conducted by evaluating emissions occurring within those nonattainment and maintenance areas.
- Beacon Wind has developed an emissions inventory for construction, operations and maintenance and decommissioning emissions for comparison to the General Conformity thresholds. The emissions inventory includes construction, operations and maintenance and decommissioning emissions that occur in nonattainment and maintenance areas impacted by the Project adjacent to the COA. Emissions in these nonattainment and maintenance areas include vessel emissions associated with the transportation of materials and construction, operations and maintenance and decommissioning activities. However, the emission inventory for the General Conformity Determination does not include emissions subject to the OCS air regulations, which will be included in the OCS permit application (i.e., emissions that occur at or within 25 mi [21.7 nm, 40.2 km] of the Lease Area).
- **Total Project Emissions:** Emissions that occur beyond 25 mi (21.7 nm, 40.2 km) from an OCS source and are not within a nonattainment or maintenance area are not regulated through the OCS Air Permit or General Conformity processes. However, to assess overall regional impacts to air quality from the proposed Beacon Wind Project and for the Bureau of Energy Management’s (BOEM) National Environmental Policy Act (NEPA) process, emissions from the Project within the United States (U.S.) (onshore and 200 nm [230.2 mi, 370.4 km] out to sea) were estimated.

FIGURE J.1-1. AIR QUALITY STUDY AREA



J.2 Geographic Allocation of Emissions

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

For example, transit emissions within 25 mi (21.7 nm, 40.2 km) of the Lease Area will be assigned to the OCS source potential emissions inventory. Transit emissions occurring in state waters will be assigned to the General Conformity potential emissions inventory for the specific nonattainment or maintenance area in which they occur, or to the attainment area potential emissions inventory for the purpose of addressing NEPA requirements. Those portions of the transit emissions that occur in waters located beyond 3 nm (3.5 mi, 5.6 km) from shore and also beyond 25 mi (21.7 nm, 40.2 km) from the Lease have not been included in the NEPA inventory only.

Beacon Wind will utilize the South Brooklyn Marine Terminal (SBMT) as the primary local port and staging area during construction and operation and maintenance of the Project, with the following exceptions:

- Port of Albany on the Hudson River in upstate New York is assumed to be the starting point for the wind turbine towers themselves (regardless of foundation design option). Vessels coming from the Port of Albany will pass through New York and New Jersey state waters;
- Satellite location located in New Bedford, Massachusetts for smaller transit vessels used during operations and maintenance;
- A yet-to-be-determined port in the Corpus Christi, Texas area is assumed to be the starting point for the bubble curtain vessel associated with various foundation concept installations;
- Halifax, Nova Scotia is assumed to be the starting point for the transit of scour protection rock and gravel (although a local U.S. port could be selected instead as construction planning continues). Rock and gravel will be brought directly to the offshore construction locations by a fall pipe vessel; and
- New York, New Jersey, Connecticut, and Massachusetts may all be impacted by the Project either from on land activities or by vessels traversing state waters.

J.2.1 Vessel Transits

To determine the maximum potential transit emissions, transit distances from the Lease Area to SBMT and from a Texas port to the Lease Area were used to allocate vessel transit emissions by geographic area. To determine likely vessel routes to calculate transit distances, vessel traffic taken from Marine Cadastre was evaluated. **Figure J.2-1** and **Figure J.2-2** illustrate this traffic data along with estimated vessel routes to and from the Project Area and staging areas.

- SBMT to center of the Lease Area (each way):
  - Kings County, New York: 10.0 nm (18.5 km);
  - Queens County, New York: 4.5 nm (8.3 km);
  - Other Federal waters: 126.5 nm (234.3 km);
  - OCS edge to center of Lease Area: 36.0 nm (66.7 km); and
  - **TOTAL:** 177.0 nm (327.8 km).

- New Bedford to center of the Lease Area (each way):
  - Bristol County, Massachusetts: 16.5 nm (30.6 km);
  - Other Federal waters: 21.5 nm (39.8 km);
  - OCS edge to center of Lease Area: 26 nm (48.2 km); and
  - **TOTAL:** 64.0 nm (118.5 km).

- Texas port to center of the Lease Area (one-way transit):
  - State waters within Corpus Christi - Victoria Air Quality Control Region (AQCR), Texas: 30.3 nm (56.1 km);
  - Other Federal waters: 2174.5 nm (4,027.2 km);
  - OCS edge to center of Lease Area: 26.9 nm (49.8 km); and
  - **TOTAL:** 2,231.7 nm (4,133.1 km).

FIGURE J.2-1. SBMT TO LEASE AREA

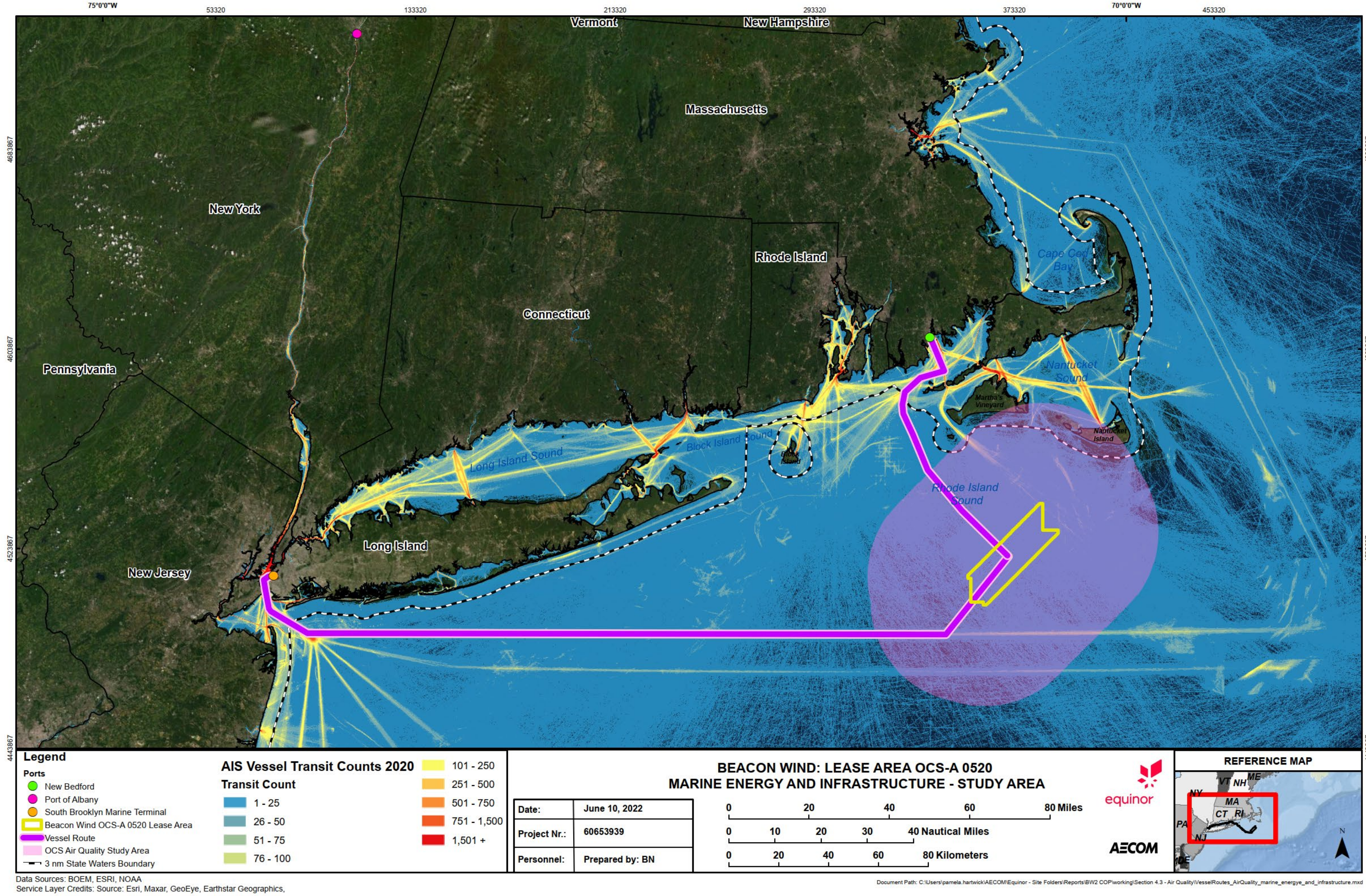
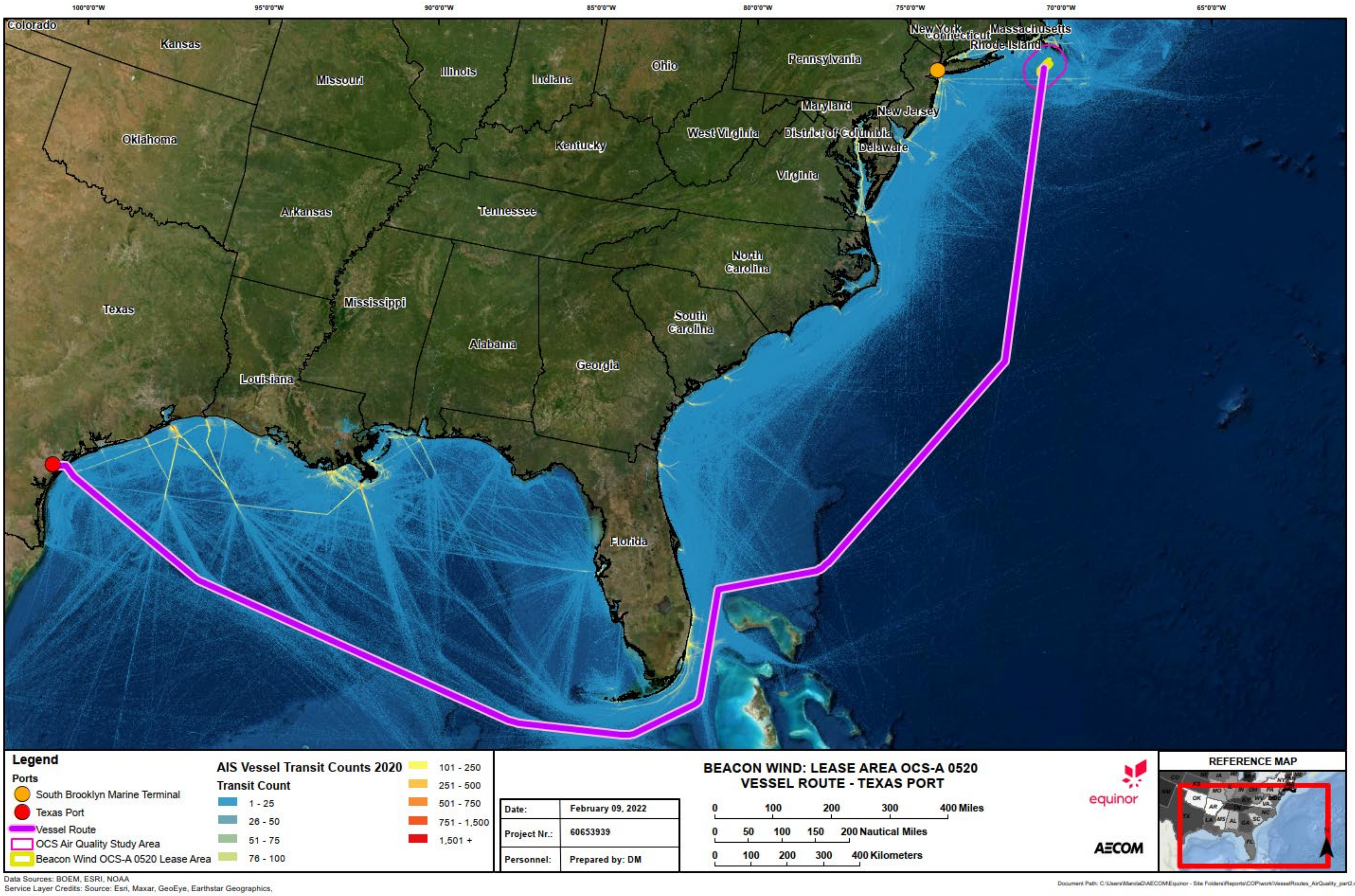


FIGURE J.2-2. TEXAS PORT TO LEASE AREA



Timing for each trip assumes an average transit speed of 6 knots (11.1 km/hour) for tugs and barges, and 12 knots (22.2 km/hr.) for other vessels.

Emissions for the transits located within the 25-mi (21.7 nm, 40.2 km) OCS source perimeter are inventoried as a prescreening for applicability for the OCS air permit.

Emissions for the transits located within state waters are inventoried either for the General Conformity assessments (if within a designated nonattainment or maintenance area) or for NEPA purposes (if located outside a designated nonattainment or maintenance area).

Emissions for those portions of transits that are outside the 25-mi (21.7 nm, 40.2 km) OCS source perimeter (and are also outside state waters) but within U.S. waters have been inventoried for inclusion in overall Project potential emissions for NEPA purposes. Vessels traveling outside U.S. waters have not been inventoried when not traveling within the 25-mi (21.7 nm, 40.2 km) OCS source perimeter. Generally, this results in exclusion of most of the ocean-crossing transit distance from overseas ports until they enter U.S. waters.

J.2.2 Port of Albany Transit

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

- Southbound counties along the Hudson River (Port of Albany to SBMT):
  - Albany County, New York: 10.0 nm (18.4 km);
  - Greene County, New York: 22.7 nm (42.0 km);
  - Ulster County, New York: 33.5 nm (62.0 km);
  - Orange County, New York: 18.0 nm (33.3 km);
  - Rockland County, New York: 21.6 nm (40.0 km);
  - Bergen County, New Jersey: 12.7 nm (23.5 km);
  - Hudson County, New Jersey: 7.5 nm (13.9 km);
  - Kings County, New York: 2.0 nm (3.7 km); and
  - **TOTAL:** 128.0 nm (237.0 km).

- Northbound counties along the Hudson River (SBMT to Port of Albany):
  - Albany County, New York: 0.1 nm (0.2 km);
  - Rensselaer County, New York: 10.0 nm (18.4 km);
  - Columbia County, New York: 26.0 nm (48.2 km);
  - Dutchess County, New York: 39.9 nm (73.9 km);
  - Putnam County, New York: 8.2 nm (15.2 km);
  - Westchester County, New York: 27.0 nm (50.0 km);
  - Bronx County, New York: 2.2 nm (4.1 km);
  - New York County, New York: 12.9 nm (23.9 km);
  - Kings County, New York: 1.8 nm (3.3 km); and
  - **TOTAL:** 128.0 nm (237.1 km).

- SBMT to center of the Lease Area (each way):
  - Kings County, New York: 10.0 nm (18.5 km);
  - Queens County, New York: 4.5 nm (8.3 km);
  - Other Federal waters: 126.5 nm (234.3 km);
  - OCS edge to center of Lease Area: 36.0 nm (66.7 km); and
  - **TOTAL:** 177.0 nm (327.8 km).

J.2.3 Submarine Export Cable Construction

Emissions from construction of the BW1 submarine export cable and onshore landfall will occur along a submarine export cable route from the Lease Area to the onshore POI in Queens, New York. This will be the same for the BW2 option that also goes to Queens, New York. A portion of the submarine export cable routes are located within 25 mi (21.7 nm, 40.2 km) of the Lease Area (and these construction emissions will be part of the OCS source potential to emit). The remainder of the submarine export cable routes are located in non-OCS ("Other") federal waters and state waters. For vessels used in construction of the submarine export cables, the air emissions were divided proportionally into each geographic area as follows:

- BW1 and BW2 (Queens, New York) cable landfalls to center of Lease Area (each way):
  - Queens County, New York: 8.3 nm (15.4 km);
  - Nassau County, New York: 17.6 nm (32.6 km);
  - Suffolk County, New York: 82.1 nm (152.0 km);
  - Other Federal waters: 38.3 nm (70.9 km);
  - Inside OCS radius: 26.7 nm (49.4 km); and
  - **TOTAL:** 173.0 nm (320.4 km).

For vessels used in construction of the BW2 submarine export cable that would go to Waterford, Connecticut, the air emissions were divided proportionally into each geographic area as follows:

- BW2 (Waterford, Connecticut) cable landfall to center of Lease Area (each way):
  - New London County, Connecticut: 4.8 nm (8.9 km);
  - Suffolk County, New York: 20.5nm (38.0 km);
  - Other Federal waters: 38.3 nm (70.9 km);
  - Inside OCS radius: 26.7 nm (49.4 km); and
  - **TOTAL:** 90.3 nm (167.2 km).

J.2.4 Helicopter Transits

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

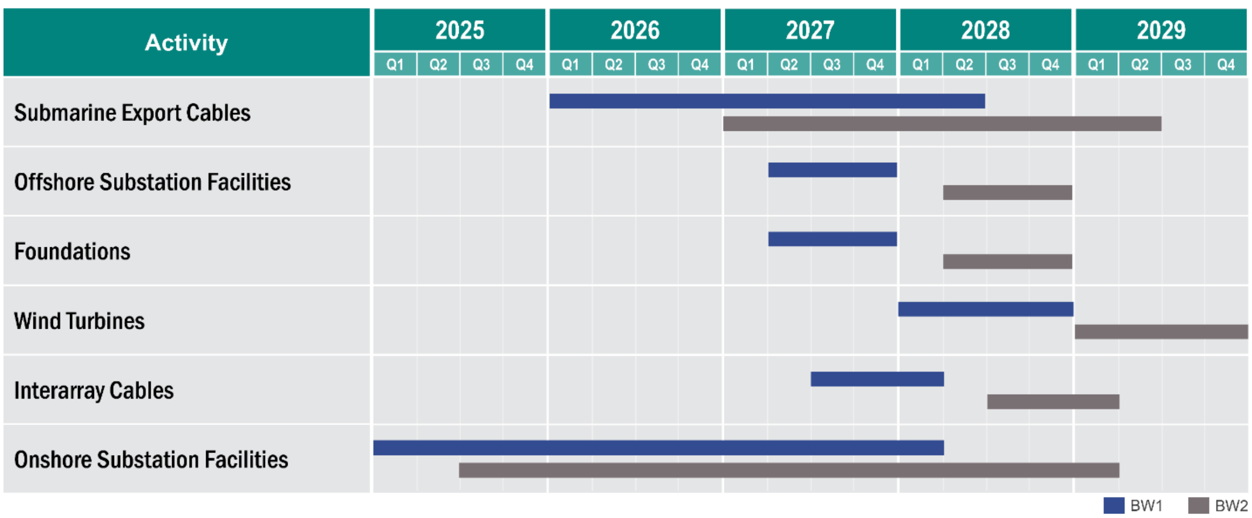
For the foundation and wind turbine generator installation tasks, distances were based on a straight-line route to the center of the Lease Area. Travel distances across each of the jurisdictional areas were calculated to be as follows:

- JFK International Airport to center of Lease Area (each way):
  - Queens County, New York: 1.9 statute mi (3.1 km);
  - Nassau County, New York: 16.8 statute mi (27.0 km);
  - Suffolk County, New York: 33.2 statute mi (53.4 km);
  - Other Federal waters: 84.5 statute mi (136.0 km);
  - Inside OCS radius: 34.3 statute mi (55.2 km); and
  - **TOTAL:** 170.7 statute mi (274.7 km).

J.3 Construction Schedule

An anticipated construction schedule for the construction and development of the BW1 and BW2 infrastructure is provided in **Figure J.3-1** below. Construction schedules are subject to various factors, for example, state and federal permitting, financial investment decisions, power purchase contracts, and supply chain considerations. Therefore, flexibility on construction schedules, particularly in staged construction, is important. As such, the Project Design Envelope (PDE) covers reasonably foreseeable schedule scenarios, from which maximum design scenarios are selected as part of the assessment process. Based on the indicative schedule, offshore construction is expected to commence in 2026, with first power expected in 2029. Commissioning emissions were assigned to calendar year 2029 for BW1 and 2030 for BW2.

FIGURE J.3-1. BW1 ANTICIPATED CONSTRUCTION SCHEDULE



For emission calculations, Beacon Wind's engineering team provided the number of vessel trips and operating days per activity required for the construction of the full BW1 and BW2 build-out.

J.4 Emissions Within 25 miles of the Source

Emissions from OCS sources and vessels traveling within 25 mi (21.7 nm, 40.2 km) of these sources need to be included in the OCS air permit application. The majority of the emissions occurring at or within 25 mi (21.7 nm, 40.2 km) of the Lease Area will be generated by Project-related construction, operations and maintenance and decommissioning vessels, broadly classified as CMVs. Specifically, emissions are generated from the main engines/generators and auxiliary engines/generators associated with these vessels. Helicopters used to transfer crew to and from the Lease Area will also be a source of air emissions, along with generator engines on the offshore substation facilities and fugitive emissions of SF_6 from the switchgear.

Methods for calculating criteria pollutants, HAPs, and GHG emissions for the respective emission source categories are summarized in **Sections J.4.1 through J.4.4**. GHG emissions are presented as “CO_2 equivalent” or CO_2e, because the different GHG constituents have different heat absorption capacities.

J.4.1 Commercial Marine Vessels (CMVs)

The calculations presented are based on assumed typical vessels representative of the types, configurations, and sizes that the Project anticipates will be employed during the construction and operation and maintenance phases of the Project. Vessel specifications have been selected to represent a maximum design scenario with respect to the potential emissions of the identified vessel category. Actual vessels to be employed during construction and operation and maintenance activities are subject to change. For instance, Beacon Wind is actively collaborating with a naval architect to assess the concept of a fully decarbonized service operation vessel (SOV) that will allow for zero emissions during operations. While current emission calculations are not assuming such a vessel is utilized, it is anticipated that this technology could be ready for implementation for Beacon Wind operations. Vessel operating durations are based on anticipated schedules provided by the Project and may also be subject to change. However, the durations presented within have been selected to represent a maximum design scenario with respect to potential emissions (i.e., conservative estimates).

J.4.1.1 Emission Methodology

Emissions were calculated using the methodology detailed within:

- BOEM’s 2021 “*BOEM Offshore Wind Energy Facilities Emission Estimate Tool – Version 2.0*” (Wind Energy Tool V2) and associated User’s Guide (Chang et al 2021);
- BOEM’s 2017 “BOEM Offshore Wind Energy Facilities Emission Estimating Tool – Technical Documentation” (Chang et al 2017); and
- EPA’s 2020 “Port Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions” (EPA’s 2020 Port Emissions Report) (EPA 2020a).

For each CMV, emissions are generated from the following:

- Main engine(s) while in transit;
- Main engine(s) while maneuvering (on site);
- Auxiliary engine(s) while in transit; and
- Auxiliary engine(s) while maneuvering (on site).

Based on what is included in BOEM's Wind Energy Tool V2 model and assumptions on chosen CMVs, emissions from CMVs do not include boiler operations. It is assumed that the vessels used within the Project Area contain unfired boilers that will heat water using excess heat from the vessel's engines.

Per BOEM's 2021 Wind Energy Tool V2 User Guide (Chang et al 2021) and EPA's 2020 Port Emissions Report (EPA 2020a), vessel emissions within 25 mi (21.7 nm, 40.2 km) of the Project are calculated using the following equations.

J.4.1.1.1 Category 3 Engine Emissions Equations:

Hours

$$HR = \left(\frac{(D*VC*TR*2)}{SP}\right) \quad \text{[Equation 1]}$$

Where:

HR = hours of operation in operation mode
D = distance travelled in operation mode
VC = vessel count
TR = trips
SP = vessel speed in operation mode (knots)

Main (Propulsion) Engine Emissions

$$V_{Pt,X} = 1.1023E^{-6}\ x\ EF_{Px}\ x\ HR\ x\ PRa \quad \text{[Equation 2]}$$

Where:

$V_{Pt,X}$ = propulsion (main engine) emissions of pollutant X (tons)
EF_{Px} = propulsion emission factor for pollutant X (grams per kilowatt hour [g/kWh])
HR = hours of operation during operation mode
PRa = engine power rating during operation mode (kilowatt [kW])
$1.10231E^{-6}$ = gram (g) to ton conversion factor

Main (Propulsion) Engine Power Rating and Load Factors

$$PRa = PR\ x\ \left(\frac{Vi}{Vref}\right)^3 \quad \text{[Equation 3]}$$

Where:

PRa = engine power rating during operation mode (kW)
PR = total installed propulsion power (kW)
V_i = average speed in operating mode (knots)
V_{ref} = maximum speed (knots)

Note: $\left(\frac{Vi}{Vref}\right)^3$ is referred to as a Load Factor in BOEM's Wind Energy Tool V2. The BOEM Load Factor default is 0.82 during transit operations and 0.20 during maneuvering operations. Propulsion load factors were replaced with those calculated based on **Equation 3**. If transit speed is unknown, default speed ratios per vessel type noted in Table 3.12 of EPA's 2020 Port Emissions Report were utilized. If maneuvering speeds are unknown, the BOEM default factor of 0.20 was utilized.

Based on what is included in BOEM's Wind Energy Tool V2 model and assumptions on chosen CMVs, emissions from CMVs do not include boiler operations. It is assumed that the vessels used within the Project Area contain unfired boilers that will heat water using excess heat from the vessel's engines.

Per BOEM's 2021 Wind Energy Tool V2 User Guide (Chang et al 2021) and EPA's 2020 Port Emissions Report (EPA 2020a), vessel emissions within 25 mi (21.7 nm, 40.2 km) of the Project are calculated using the following equations.

J.4.1.1.1 Category 3 Engine Emissions Equations:

Hours

$$HR = \left(\frac{(D*VC*TR*2)}{SP}\right) \quad \text{[Equation 1]}$$

Where:

HR = hours of operation in operation mode
D = distance travelled in operation mode
VC = vessel count
TR = trips
SP = vessel speed in operation mode (knots)

Main (Propulsion) Engine Emissions

$$V_{Pt,X} = 1.1023E^{-6}\ x\ EF_{Px}\ x\ HR\ x\ PRa \quad \text{[Equation 2]}$$

Where:

$V_{Pt,X}$ = propulsion (main engine) emissions of pollutant X (tons)
EF_{Px} = propulsion emission factor for pollutant X (grams per kilowatt hour [g/kWh])
HR = hours of operation during operation mode
PRa = engine power rating during operation mode (kilowatt [kW])
$1.10231E^{-6}$ = gram (g) to ton conversion factor

Main (Propulsion) Engine Power Rating and Load Factors

$$PRa = PR\ x\ \left(\frac{Vi}{Vref}\right)^3 \quad \text{[Equation 3]}$$

Where:

PRa = engine power rating during operation mode (kW)
PR = total installed propulsion power (kW)
V_i = average speed in operating mode (knots)
V_{ref} = maximum speed (knots)

Note: $\left(\frac{Vi}{Vref}\right)^3$ is referred to as a Load Factor in BOEM's Wind Energy Tool V2. The BOEM Load Factor default is 0.82 during transit operations and 0.20 during maneuvering operations. Propulsion load factors were replaced with those calculated based on **Equation 3**. If transit speed is unknown, default speed ratios per vessel type noted in Table 3.12 of EPA's 2020 Port Emissions Report were utilized. If maneuvering speeds are unknown, the BOEM default factor of 0.20 was utilized.

J.4.1.1.2 Category 1 and 2 Engine Emissions Equations:

Hours

See **Equation 1** above.

Main (Propulsion) and Auxiliary Engine Emissions

$V_X = 1.1023E^{-6}\ x\ EF_x\ x\ HR\ x\ P\ x\ LF$ [Equation 7]

Where:

V_X = engine emissions of pollutant X (tons)
EF_x = engine emission factor for pollutant X (g/kWh)
HR = hours of operation in operation mode
P = engine maximum power rating (kW)
LF = load factor
$1.10231E^{-6}$ = g to ton conversion factor

Main (Propulsion) Engine Load Factor

$LF = \frac{FC_p}{BSFC\ x\ P_p\ x\ A}$ [Equation 8]

Where:

LF = load factor
FC_p = average propulsion engine fuel consumption (grams)
BSFC = Brake specific fuel consumption (g/kWh) as provided in Table 4.3 of EPA's 2020 Port Emission Report. (248 with kW < 37; 213 with kW ≥ 37)
Pp = installed propulsion power (kW)
A = hours of operation

Note: Fuel consumption can be converted from gallons to grams using factor of 3,200 gram per gallon (g/gal) for diesel. If the Load Factor could not be calculated, default factors taken from Table 4.4 of the EPA's 2020 Port Emissions Report were utilized. If local factor could not be determined for dredging vessels, a factor of 0.66 was applied (EPA 2020a). The factors provided in Table 4.4 of the EPA's 2020 Port Emissions Report do not vary per operating mode (EPA 2020a). The BOEM default Load Factors are 0.82 during transit operations and 0.20 during maneuvering operations. These values were replaced with those derived following EPA's 2020 Port Emissions Report.

Auxiliary Engine Load Factor

Per Table 4.4 in the EPA's 2020 Port Emissions Report, a Load Factor of 0.43 was applied for auxiliary engines for all operating modes. If a local factor could not be determined for dredging vessels, a factor of 0.66 was applied. The BOEM default Load Factors are 1 during transit operations and 1 during maneuvering operations. These values were replaced with those derived following EPA's 2020 Port Emissions Report.

Total CMV Emissions

See **Equation 6** above.

J.4.1.2 Emission Factors

J.4.1.2.1 Criteria Pollutants and GHGs

Emission factors in units of g/kWh for criteria pollutants and GHGs were taken from EPA's 2020 Port Emissions report, as also used by BOEM's Wind Energy Tool V2. Emission factors are provided based on vessel engine categories (Categories 1, 2, and 3), group (propulsion, auxiliary), fuel type, and engine type. It is assumed the CMVs used for the Project have an engine type of medium-speed diesel (MSD) and operates with distillate marine gas oil (MGO) or marine diesel oil (MDO). For conservatism, most engines are assumed to comply with Tier I standards unless the engine is known to be a higher Tier. In reality, there will be a mix of Tier I, II, III, and IV engines. Emission factors are presented in **Table J.4-1** below.

Category 3 Details

- PM_{10} emission factors are calculated based on the following equation:

  Category 3 PM_{10} Emission Factor:

  $EF_{PM10} = PM_{Base} + (S_{act}\ x\ BSFC\ x\ FSC\ x\ MWR)$ [Equation 9]

  Where:

  EF_{PM10} = PM_{10} emission factor
  PM_{Base} = base emission factor assuming zero fuel sulfur (0.1545 g/kWh for MGO/MDO)
  S_{act} = actual fuel sulfur level (weight ratio) (0.001 for most vessel activity in 2015 and beyond)
  BSFC = brake specific fuel consumption (g/kWh) as provided in Table 3.6 of EPA's 2020 Port Emissions report (205 g/kWh for MSD, MGO/MDO – propulsion and 217 g/kWh for MSD, MGO/MDO – auxiliary)
  FSC = fraction of sulfur in fuel that is converted to direct sulfate PM (0.02247)
  MWR = molecular weight ratio of sulfate PM to sulfur (224/32 = 7)

- $PM_{2.5}$ emission factor is 92 percent of PM_{10} and the black carbon emissions are three percent of $PM_{2.5}$.
- The EPA's 2020 Port Emissions Report provides only a hydrocarbon (HC) emission factor. The VOC emission factor is 1.053 times the HC factor and CH_4 is two percent of the HC factor.
- CO_2 emission factors are calculated based on the following equation:

  Category 3 CO_2 Emission Factor:

  $EF_{CO2} = BSFC\ x\ CCF$ [Equation 10]

  Where:

  EF_{CO2} = CO_2 emission factor
  BSFC = brake specific fuel consumption (g/kWh) as provided in Table 3.6 of EPA's 2020 Port Emissions report (205 g/kWh for MSD, MGO/MDO – propulsion and 217 g/kWh for MSD, MGO/MDO – auxiliary)
  CCF = carbon content factor, which varies by fuel type (g CO_2/g fuel) (3.206 for MGO/MDO)

- The SO_2 emission factor is calculated based on the following equation:

Category 3 SO_2 Emission Factor:

$EF_{SO2} = BSFC \; x \; S_{act} \; x \; FSC \; x \; MWR$ [Equation 11]

Where:

EF_{SO2} = SO_2 emission factor (g/kWh)
BSFC = brake specific fuel consumption (g/kWh) as provided in Table 3.6 of EPA's 2020 Port Emissions report (205 g/kWhr for MSD, MGO/MDO – propulsion and 217 g/kWh for MSD, MGO/MDO – auxiliary)
S_{act} = actual fuel sulfur level (weight ratio) (0.001 for most vessel activity in 2015 and beyond)
FSC = fraction of sulfur in fuel that is converted to SO_2 (0.97753)
MWR = molecular weight ratio of SO_2 to sulfur (64/32 = 2)

- Other emission factors (NO_x, CO, and N_2O) are taken directly from EPA's 2020 Port Emissions report, specifically Table 3.5, Table 3.8, and Table 3.9.

Category 1 and 2 Details

- NO_x, PM_{10}, $PM_{2.5}$, CO, VOC, SO_2, and CO_2 emission factors are based on average Harbor Craft emission factors from Table H.7 of EPA's 2020 Port Emissions report. Emission factors are the same for propulsion and auxiliary engines.
- The black carbon emission factor is 77 percent of $PM_{2.5}$.
- The CH_4 emission factor is 2 percent of the HC emission factor. However, Table H.7 of EPA's 2020 Port Emissions report did not provide the average HC factor but instead the average VOC factor. Since the VOC factor is based on 1.053 times the HC factor, the HC factor was back-calculated based on this relationship.
- The N_2O emission factor is calculated based on the following equation:

Category 1 and 2 N_2O Emission Factor:

$EF_{N2O} = BSFC \; x \; NCF$ [Equation 12]

Where:

EF_{N2O} = N_2O emission factor (g/kWh)
BSFC = brake specific fuel consumption (g/kWh) as provided in Table 4.3 of EPA's 2020 Port Emission report. (248 with kW < 37; 213 with kW ≥ 37)
NCF = N_2O conversion factor (g N_2O/g fuel) [0.000156]

To determine greenhouse gas emissions in terms of CO_2e, global warming potential (GWP) factors were utilized. Each GHG constituent has a different heat trapping capability. The corresponding GWP has been calculated 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. The 100-year GWP of 28 for CH_4 and 265 for N_2O were used. These GWPs are from the Fifth Assessment Report (AR5) produced by the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2014). For comparison to typical EPA CO_2e totals and New York State CO_2e totals, Fourth Assessment Report (AR4) 100-year GWPs were also applied (25 for CH_4

and 298 for N_2O) along with AR5 20-year GWPs (84 for CH_4 and 264 for N_2O). **Equation 13** below illustrates how the CO_2e emissions are calculated.

CO_2e Emissions:

$$E_{CO2e} = CO_2 + (CH_4 \; x \; GWP_{CH4}) + (N_2O \; x \; GWP_{N2O}) \qquad \text{[Equation 13]}$$

Where:

E_{CO2e} = total CO_2e emissions (tons)
CO_2 = total CO_2 emissions (tons)
CH_4 = total CH_4 emissions (tons)
N_2O = total N_2O emissions (tons)
GWP_{CH4} = GWP for CH_4
GWP_{N2O} = GWP for N_2O

TABLE J.4-1. CRITERIA AND GHG POLLUTANT EMISSION FACTORS FOR CMVS

Category	Engine Group	Fuel Type	Engine Type	Tier	NOx (g/kWh)	PM_{10} (g/kWh)	$PM_{2.5}$ (g/kWh)	Black Carbon (g/kWh)	CO (g/kWh)	VOC (g/kWh)	SO_2 (g/kWh)	CO_2 (g/kWh)	CH_4 (g/kWh)	N_2O (g/kWh)
3	Propulsion	MGO/ MDO	MSD	I	12.2	0.187	0.172	0.005	1.1	0.53	0.401	657.23	0.010	0.029
	Auxiliary				9.80	0.189	0.174	0.005	1.1	0.42	0.424	695.70	0.008	0.029
	Propulsion	MGO/ MDO	MSD	2	10.5	0.187	0.172	0.005	1.1	0.53	0.401	657.23	0.010	0.029
	Auxiliary				7.7	0.189	0.174	0.005	1.1	0.42	0.424	695.70	0.008	0.029
	Propulsion	MGO/ MDO	MSD	3	2.6	0.187	0.172	0.005	1.1	0.53	0.401	657.23	0.010	0.029
	Auxiliary				2.0	0.189	0.174	0.005	1.1	0.42	0.424	695.70	0.008	0.029
1, 2	Propulsion and Auxiliary	MGO/ MDO	MSD	1	9.62	0.259	0.251	0.193	1.61	0.30	0.006	679.47	0.006	0.039 (< 37 kW) 0.033 (≥ 37 kW)
	Propulsion and Auxiliary	MGO/ MDO	MSD	2	5.64	0.148	0.144	0.111	0.92	0.30	0.006	679.47	0.006	0.039 (< 37 kW) 0.033 (≥ 37 kW)
	Propulsion and Auxiliary	MGO/ MDO	MSD	3	4.75	0.083	0.081	0.062	0.92	0.125	0.006	679.47	0.002	0.039 (< 37 kW) 0.033 (≥ 37 kW)
	Propulsion and Auxiliary	MGO/ MDO	MSD	4	1.30	0.030	0.029	0.022	0.92	0.125	0.006	679.47	0.002	0.039 (< 37 kW) 0.033 (≥ 37 kW)

J.4.1.2.2 HAPs and Pb

Emission factors for HAPs and Pb are provided by EPA's 2020 Port Emissions report, Table D.1. The emission factors for individual HAP compounds and Pb are provided as fractions of the $PM_{2.5}$ or VOC emissions from the CMVs. **Equation 14** below demonstrates how these fractions are applied to calculate HAP and Pb emissions.

HAP and Pb Emissions:

$E_{HAP} = (VOC\ x\ SF_{VOC})\ or\ (PM_{2.5}\ x\ SF_{PM2.5})$ [Equation 14]

Where:

E_{HAP} = total HAP or Pb emissions (tons)
VOC = total VOC emissions (tons)
$PM_{2.5}$ = total $PM_{2.5}$ emissions (tons)
SF_{VOC} = speciated fraction for VOC
$SF_{PM2.5}$ = speciated fraction for $PM_{2.5}$

EPA's 2020 Port Emissions report does not differentiate the speciated fractions based on operating mode (for example, in transit or maneuvering) or engine type (main/propulsion or auxiliary) so the same fractions were used for each operating mode and for each engine type.

J.4.1.3 Fuel Consumption

Fuel consumption (in gallons) for each CMV was calculated using **Equation 15** below and is based on an assumed fuel rate (kilogram [kg] per vessel per day) provided by the Project and a fuel density of 3.18 kilogram per gallon (kg/gal).

CMV Fuel Consumption:

$FC = \frac{Fuel\ Rate\ (\frac{kg}{day})}{3.18\frac{kg}{gal}}\ x\ Operating\ Days$ [Equation 15]

J.4.2 Helicopters

One helicopter is currently assumed to be used to perform crew transfers during the foundation installation, wind turbine installation, and submarine export cable installation tasks. Emission factors were taken from the BOEM Wind Energy Tool V2's User Guide (Chang et al 2021). The helicopter to be used for these crew transfers is assumed to be a large twin-engine helicopter capable of carrying 20 to 30 passengers. The "Twin Heavy" helicopter category was selected from the BOEM technical document. Emissions were calculated based on the following equation.

Helicopter Emissions:

$EH = Hours\ x\ EF\ x\ \frac{1\ ton}{2000\ lbs}$ [Equation 16]

Where:

E_H = helicopter emissions (tons)
EF = pollutant emission factors (pounds per hour [lb/hr.])

Table A-5 of the BOEM document provides default airspeeds for each category of helicopter size. For a Twin Heavy helicopter, default airspeed is 188.2 miles per hour. Although the airport for helicopter flights has not been selected, travel distances and durations were estimated using JFK International Airport as the assumed departure location. Emissions were based on two round trips per week for the duration of foundation, wind turbine, and submarine export cable installation tasks for each phase, with a round trip duration of 109 minutes per flight.

J.4.2.1 Emission Factors

Table A-2 of the BOEM Wind Energy Tool V2 User Guide and Table 4 of the original BOEM 2017 technical document provide 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 per hour (gal/hr), based on four categories of helicopter size. **Table J.4-2** notes these factors for the Twin Heavy helicopter category.

TABLE J.4-2. SUPPORT HELICOPTER EMISSION FACTORS

Helicopter Type	Fuel Usage (gal/hr)	Emission Factors (lb/hr)									
		CO_2	CH_4	N_2O	Black Carbon	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC
Twin Heavy	314.74	6,640.46	0.19	0.22	0.105	0.82	34.66	0.80	0.804	2.11	2.67

To determine GHG emissions in terms of CO_2e, the same methodology described in **Section J.4.1.3.1** was utilized.

The BOEM Wind Energy Tool does not calculate HAP and Pb emissions. Thus, emissions of HAPs and Pb for the helicopter engines were based on factors presented in EPA's AP-42 Compilation of Air Pollutant Emission Factors (AP-42) Section 3.4 for large diesel engines (EPA 1996) and the paper *Survey of Ultra-Trace Metals in Gas Turbine Fuels* (Rising et al 2004).

J.4.2.2 Fuel Consumption

Fuel consumption was calculated using the default BOEM Wind Energy Tool fuel usage rate (gal/hr) for Twin Heavy helicopters and total flight hours.

J.4.3 Offshore Substation Facilities - Stationary Diesel Generators

The offshore substation facilities are assumed to be equipped with one diesel generator engine rated at 600 kW mechanical output each. The offshore substation facilities generator engines are assumed to be used for both emergency and non-emergency generation. Potential emissions were estimated by conservatively assuming up to 500 operating hours per year for each engine.

J.4.3.1 NO_x, CO, VOC and PM Emissions

Emissions of NO_X, CO, VOC, and PM from these engines were assumed to meet the corresponding EPA Tier 4 final emission standards in Table 1 of 40 CFR §1039.101 for non-emergency engines of the appropriate size category. These factors are in units of g/kWh. PM is assumed to be PM_{10} and 97 percent of the PM is assumed to be $PM_{2.5}$. This is based on EPA's report, "Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition" (EPA 2010).

Emission rates 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 (453.59 grams per pound [g/lb]) and by the conversion factor from pounds to ton (2,000 pounds per ton [lb/ton]). See equation below.

Emission Rate (g/kWh) Conversion:

$$E = \frac{g}{kWh} \; x \; kW \; x \frac{hr}{yr} \; x \frac{lb}{453.59\ g} \; x \frac{ton}{2000\ lb} \qquad \text{[Equation 17]}$$

Where:

E = NOx, CO, VOC, and PM emissions (tons)

J.4.3.2 SO_2, HAP and Pb Emissions

Emissions of SO_2 were based on a mass balance assuming a fuel sulfur content of 0.0015 percent by weight (15 parts per million [ppm]), and 100 percent conversion of fuel sulfur to SO_2. See equation below.

SO_2 emission rate:

$$ERSO2 = \frac{0.000015\ lb\ S}{lb\ diesel\ fuel} \; x \frac{1\ lb\ mole\ S}{32\ lb\ S} \; x \frac{1\ lb\ mole\ SO2}{1\ lb\ mole\ S} \; x \frac{64\ lb\ SO2}{1\ lb\ mole\ SO2} \div \frac{Btu}{lb} \; x \frac{10^6 Btu}{MMBtu} \qquad \text{[Equation 18]}$$

Where:

ER_{SO2} = SO_2 emission rate (lb/million British thermal units [MMBtu])

Emissions of HAPs and Pb for the engines were based on factors presented in EPA's AP-42 Section 3.4 for large diesel engines, in units of lb/MMBtu (EPA 1996) and the paper *Survey of Ultra-Trace Metals in Gas Turbine Fuels* (Rising et al 2004).

SO_2, HAP, and Pb emissions using lb/MMBtu emission factors were calculated by multiplying by the heat input rate (million British thermal units per hour [MMBtu/hr]) (calculated from generator's fuel consumption [gallon]) and the diesel fuel's heat content [Btu/gal]), and by the total annual operating hours, converting from pounds to tons (2,000 lb/ton). See equation below.

Emission Rate (lb/MMBtu) Conversion:

$$E = \frac{lb}{MMBtu} \; x \frac{MMBtu}{hr} \; x \frac{hr}{yr} \; x \frac{ton}{2000\ lb} \qquad \text{[Equation 19]}$$

Where:

E = SO_2 , HAP, and Pb emissions (tons)

J.4.3.3 GHG Emissions

Emissions for GHG pollutants were based on the emission factors presented in 40 CFR §98 Tables C-1 and C-2 for Distillate Fuel No. 2. The factors from 40 CFR §98 are in units of kilogram per million British thermal units (kg/MMBtu). These emission rates were first converted to lb/MMBtu by multiplying by 2.20462 pound per kilogram (lb/kg). Once the emission rate was in units of lb/MMBtu, emissions were calculated using the same methodology noted in **Equation 16** above. Conversion to CO_2e followed the same GWPs and methodology as noted for the CMVs.

J.4.4 Portable Diesel Generator Engines

A number of portable diesel generator engines will be required during construction and commissioning of the Project, as well as during potential unplanned emergency events during operations and maintenance of the Project. Emissions were estimated based on guidance and past experience and will be updated as the project progresses.

As noted in **Section J.4.3**, for the portable diesel generators that will be hoisted onto an offshore substation facility or wind turbine platform, emissions of NO_X, CO, VOC, and PM were assumed to meet the corresponding post-2014 nonroad emission standards in Table 1 of 40 CFR §1039.101 for generator sets of the appropriate size category. Emissions of SO_2 were based on a mass balance assuming a fuel sulfur content of 0.0015 percent by weight, and 100 percent conversion of fuel sulfur to SO_2. Emissions of HAPs and Pb for the engines were based on factors presented in AP- 42 Section 3.3 for small diesel engines (EPA 1996a) and the paper *Survey of Ultra-Trace Metals in Gas Turbine Fuels* (Rising et al 2004). Emissions for GHG pollutants (CO_2, CH_4, and N_2O) were based on the emission factors presented in 40 CFR §98 Tables C-1 and C-2.

Since the 1,200-kW wind turbine installation engine and the 500-kW offshore substation facilities commissioning engine could potentially be a marine vessels' own generator engine, emissions for the pollutants from these engines were conservatively estimated using the emission factors described in **Section J.4.1** for Category 2 marine engines, unless specific engines were known by the developer at the time of application.

J.4.5 Offshore Substation Facilities - Gas-Insulated Switchgears

The offshore substation facilities platforms and wind turbines will be equipped with high-voltage circuit breakers (switchgear) that use SF_6 gas as an insulating material. SF_6 is a GHG that slowly leaks from the sealed switchgear housings into the air. The offshore substation facilities platforms are still being designed and information about the proposed switchgear will be included in a future supplement to the COP. Emissions of SF_6 from the wind turbine switchgear were estimated using the switchgear counts and storage quantities provided by the Project, and assuming an annual leakage rate of 0.5 percent by weight per year (IEC 2004). Note this is a lower leak rate than Massachusetts Department of Environmental Protection requires, which is 1 percent. See equation below.

SF_6 Emissions:

$$E = lb\ SF_6\ Stored\ x\ No.of\ Switches\ x \frac{0.5}{100} x \frac{ton}{2000\ lb} \quad \text{[Equation 20]}$$

Where:

E = SF_6 emissions (tons)

The conversion of SF_6 emissions to the equivalent CO_2e used the GWP of 23,500, per (AR5 produced by IPCC. For comparison purposes, the 100-year GWP of 22,800 from AR4 and 20-year GWP of 17,500 from AR5 was also applied. SF_6 emissions is included in all operational GHG CO_2e totals.

J.4.6 Decommissioning Emissions

Decommissioning emissions have been assumed to include the same marine vessels and activities as construction. However, these steps would be performed in reverse. It is important to note that advances in decommissioning methods/technologies as well as advancements in emissions reduction technologies, are expected to occur throughout the operations phase of the Project. In addition, the following equipment and/or activities would not be included in decommissioning:

- Seabed preparation vessels, such as fall pipe vessels and pre-trenching vessels;
- Bubble curtain vessels;
- Commissioning activities;
- Routine operation and maintenance activities;
- All onshore facilities, including onshore substations, transmissions cables, and the O&M Base would be assumed to remain in use or repurposed for other uses and thus no have any decommissioning emissions.

As estimated emissions, to account for future advances in decommissioning methods/technologies and emission reduction technologies, along with acknowledgement not all construction vessels and activities would be repeated for decommissioning, it is assumed future decommissioning emissions will be equivalent to 20 percent of the combined construction and commissioning emissions. It is also assumed there will be no emissions of SF_6 from the switchgear during decommissioning.

J.4.7 Emissions within 25 miles of the Source Summary

Air emissions associated with the combined BW1 and BW2 phases of the Project that are subject to the OCS Air Permit are detailed in **Table J.4-3** and **Table J.4-4** below.

TABLE J.4-3. EMISSIONS WITHIN 25 MI OF THE SOURCE (BW1 AND BW2 – QUEENS, NEW YORK)

Year/ Activity	Emissions (tons per year)													
	VOC	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	AR5 100-year CO_2e	AR4 100-year CO_2e	AR5 20-year CO_2e	Pb
Construction and Commissioning														
2025	1.02	19.30	3.16	0.51	0.48	0.53	0.27	3613.41	0.04	0.06	3,630.75	3,632.67	3,632.78	0.00003
2026	4.31	112.85	13.84	2.14	2.02	2.42	0.51	7651.08	0.08	0.35	7,747.27	7,758.72	7,751.51	0.0003
2027	296.11	7,086.39	701.78	117.50	109.15	207.09	34.66	397,881.76	5.63	17.83	402,765.58	403,337.23	403,063.00	0.014
2028	358.55	8,566.59	853.36	141.97	131.87	250.82	41.96	482,456.43	6.91	21.53	488,354.93	489,044.63	488,720.40	0.016
2029	66.85	1,598.17	167.25	26.67	24.80	46.02	7.82	93,614.56	1.37	4.12	94,743.55	94,875.28	94,815.90	0.003
2030 a/	3.11	99.14	20.05	1.87	1.81	0.63	0.45	15,682.21	0.22	0.60	18,170.04	18,120.01	17,588.67	0.0002
Operations and Maintenance														
Per Year	5.36	169.53	33.78	3.20	3.09	1.22	0.80	27,297.29	0.42	1.00	32,068.83	31,966.89	30,944.05	0.0004
Decommissioning														
Total:	145.45	3,479.53	348.51	57.81	53.72	101.38	17.05	197,450.16	2.81	8.80	199,860.36	200,142.30	200,008.75	0.007

Notes:

a/ 2030 emissions includes operation of BW1 and commissioning of BW2

TABLE J.4-4. EMISSIONS WITHIN 25 MI OF THE SOURCE (BW1 AND BW2 – WATERFORD, CONNECTICUT)

Year/ Activity	Emissions (tons per year)													
	VOC	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	AR5 100-year CO_2e	AR4 100-year CO_2e	AR5 20-year CO_2e	Pb
Construction and Commissioning														
2025	1.19	23.30	3.55	0.57	0.54	0.68	0.29	3,851.76	0.04	0.07	3,871.92	3,874.16	3,874.11	0.00004
2026	4.66	120.85	14.62	2.28	2.15	2.71	0.55	8,127.77	0.09	0.37	8,229.61	8,241.71	8,234.19	0.0003
2027	298.63	7,146.56	707.75	118.47	110.04	208.93	34.96	401,491.93	5.68	18.00	406,419.95	406,996.80	406,719.88	0.014
2028	362.15	8,652.85	861.93	143.35	133.15	253.43	42.38	487,633.34	6.98	21.76	493,595.32	494,292.48	493,964.39	0.017
2029	68.57	1,639.30	171.34	27.32	25.41	47.25	8.02	96,083.84	1.40	4.23	97,243.16	97,378.46	97,317.23	0.003
2030 a/	3.11	99.14	20.05	1.87	1.81	0.63	0.45	15,682.21	0.22	0.60	18,170.04	18,120.01	17,588.67	0.0002
Operations and Maintenance														
Per Year	5.36	169.53	33.78	3.20	3.09	1.22	0.80	27,297.29	0.42	1.00	32,068.83	31,966.89	30,944.05	0.000
Decommissioning														
Total:	147.13	3,519.45	352.47	58.45	54.31	102.60	17.25	199,844.44	2.84	8.91	202,283.94	202,569.31	202,433.99	0.007

Notes:
a/ 2030 emissions includes operation of BW1 and commissioning of BW2

J.5 General Conformity Emissions

For reference only, emissions from construction, operations and maintenance and decommissioning activities were calculated for comparison to the General Conformity thresholds. The emissions inventory includes construction, operations and maintenance and decommissioning emissions that occur in nonattainment and maintenance areas impacted by the Project. Emissions in these nonattainment and maintenance areas include vessel emissions associated with the transportation of materials and construction, operations and maintenance, and decommissioning activities. However, the emission inventory for the General Conformity Determination does not include emissions subject to the OCS air regulations, which are included in the OCS permit application (i.e., emissions that occur at or within 25 mi [21.7 nm, 40.2 km] of the Lease Area). Nonattainment and maintenance area boundaries extend to the state's seaward boundary, which is in general 3 nm (3.5 mi, 5.6 km) beyond the coastline. One exception is the Long Island Sound. Because the Long Island Sound is a juridical bay within the U.S. coastline, New York and Connecticut have jurisdiction over the Long Island Sound waters from coastal boundaries to edge of state and county boundary. Thus, nonattainment or maintenance area boundaries along the Long Island Sound are based on state and county lines versus 3 nm (3.5 mi, 5.6 km) beyond coastline.

Table J.5-1 lists the attainment status of counties and areas that may be impacted by the Project. Emissions that occur within any county or area designated as non-attainment or maintenance need to be evaluated against General Conformity de minimis thresholds to determine if a General Conformity Determination is required.

Vessels leaving the Port of Albany and the SBMT will travel through several non-attainment or maintenance counties on route to and from the Project Area. These counties are primarily a part of the New Jersey-New York-Connecticut Interstate AQCR, with Orange County, New York added for $PM_{2.5}$ comparisons.

Vessels leaving the Satellite Port in New Bedford, Massachusetts would not cross any non-attainment or maintenance counties on route to and from the Project Area.

Vessels will also travel through a few nonattainment and maintenance counties associated with the New Jersey-New York-Connecticut Interstate AQCR while installing the submarine export cable route around Long Island.

The onshore substation facility associated with BW1, and potentially BW2, in Queens is within Queens County, New York and, thus, the associated construction, operations and maintenance and decommissioning activities will have to be included with any comparisons necessary for those nonattainment and maintenance pollutants.

The onshore substation facility associated for BW2 if located in Waterford, Connecticut would be within New London County, Connecticut and within the Eastern Connecticut Intrastate AQCR. New London County is considered in nonattainment with the latest ozone standards.

The majority of the emissions occurring within the nonattainment and maintenance areas will be generated by Project-related construction, operations and maintenance and decommissioning CMVs. Specifically, emissions are generated from the main engines/generators and auxiliary engines/generators associated with these vessels. Helicopters used to transfer crew to and from the Project Area will also be a source of air emissions, along with generator engines on the onshore substation facilities, nonroad construction emissions, and construction fugitives.

TABLE J.5-1. ATTAINMENT DESIGNATIONS

<table>
<tr><th>County/State</th><th>Air Quality Control Region (AQCR)</th><th>1971 and 2010 SO_2</th><th>CO</th><th>Pb</th><th>Annual PM_{10}</th><th>1997 Annual $PM_{2.5}$</th><th>2012 Annual $PM_{2.5}$</th><th>1997 24 Hour $PM_{2.5}$</th><th>2006 24 Hour $PM_{2.5}$</th><th>NO_2</th><th>2008 8 Hour O_3</th><th>2015 8 Hour O_3</th></tr>
<tr><td>Albany/New York</td><td rowspan="8">Hudson Valley Intrastate</td><td rowspan="8">Attainment</td><td rowspan="8">Attainment/ Unclassifiable</td><td rowspan="8">Attainment/ Unclassifiable</td><td rowspan="8">Revoked/ Attainment</td><td rowspan="6">Attainment/ Unclassifiable</td><td rowspan="8">Attainment/ Unclassifiable</td><td rowspan="8">Attainment/ Unclassifiable</td><td rowspan="6">Attainment/ Unclassifiable</td><td rowspan="8">Attainment/ Unclassifiable</td><td rowspan="8">Attainment/ Unclassifiable</td><td rowspan="8">Attainment/ Unclassifiable</td></tr>
<tr><td>Rensselaer/New York</td></tr>
<tr><td>Greene/New York</td></tr>
<tr><td>Columbus/New York</td></tr>
<tr><td>Ulster/New York</td></tr>
<tr><td>Dutchess/New York</td></tr>
<tr><td>Orange/New York</td><td>Maintenance</td><td>Maintenance</td></tr>
<tr><td>Putnam/New York</td><td>Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td></tr>
<tr><td>Rockland/New York</td><td rowspan="12">New Jersey-New York-Connecticut Interstate</td><td rowspan="12">Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td><td rowspan="12">Attainment/ Unclassifiable</td><td rowspan="3">Revoked/ Attainment</td><td rowspan="12">Maintenance</td><td rowspan="12">Attainment/ Unclassifiable</td><td rowspan="12">Attainment/ Unclassifiable</td><td rowspan="12">Maintenance</td><td rowspan="12">Attainment/ Unclassifiable</td><td rowspan="12">Nonattainment (Serious)</td><td rowspan="12">Nonattainment (Moderate)</td></tr>
<tr><td>Westchester/New York</td><td rowspan="7">Maintenance</td></tr>
<tr><td>Bronx/New York</td></tr>
<tr><td>New York/New York</td><td>Nonattainment (Moderate)</td></tr>
<tr><td>Kings/New York</td><td rowspan="8">Revoked/ Attainment</td></tr>
<tr><td>Richmond/New York</td></tr>
<tr><td>Queens/New York</td></tr>
<tr><td>Nassau/New York</td></tr>
<tr><td>Suffolk/New York</td><td>Attainment/ Unclassifiable</td></tr>
<tr><td>Bergen/New Jersey</td><td rowspan="3">Maintenance</td></tr>
<tr><td>Hudson/New Jersey</td></tr>
<tr><td>Monmouth/New Jersey</td></tr>
<tr><td>New London/Connecticut</td><td>Eastern Connecticut Intrastate</td><td>Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td><td>Revoked/ Attainment</td><td>Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td><td>Nonattainment (Serious)</td><td>Nonattainment (Marginal)</td></tr>
<tr><td>Bristol/Massachusetts</td><td rowspan="2">Metropolitan Providence</td><td rowspan="2">Attainment/ Unclassifiable</td><td rowspan="2">Attainment/ Unclassifiable</td><td rowspan="2">Attainment/ Unclassifiable</td><td rowspan="2">Revoked/ Attainment</td><td rowspan="2">Attainment/ Unclassifiable</td><td rowspan="2">Attainment/ Unclassifiable</td><td rowspan="2">Attainment/ Unclassifiable</td><td rowspan="2">Attainment/ Unclassifiable</td><td rowspan="2">Attainment/ Unclassifiable</td><td>Attainment/ Unclassifiable</td><td rowspan="2">Attainment/ Unclassifiable</td></tr>
<tr><td>Dukes/Massachusetts</td><td>Nonattainment (Marginal)</td></tr>
<tr><td>Aransas/Texas</td><td rowspan="3">Corpus Christi-Victoria Intrastate</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Revoked/ Attainment</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Attainment/ Unclassifiable</td><td rowspan="3">Attainment/ Unclassifiable</td></tr>
<tr><td>Nueces/Texas</td></tr>
<tr><td>San Patricio/Texas</td></tr>
</table>

J.5.1 Commercial Marine Vessels (CMVs)

The emissions calculations presented for CMVs are based on assumed typical vessels representative of the types, configurations, and sizes that the Project anticipates will be employed during the construction and operations phases of the Project. Vessel specifications have been selected to represent a maximum design scenario with respect to the potential emissions of the identified vessel category. Actual vessels to be employed during construction and operations activities are subject to change. For instance, Beacon Wind is actively collaborating with a naval architect to assess the concept of a fully decarbonized SOV that will allow for zero emissions during operations. While current emission calculations are not assuming such a vessel is utilized, it is anticipated that this technology could be ready for implementation for Beacon Wind operations. Vessel operating durations are based on anticipated schedules provided by the Project and may also be subject to change. However, the durations presented within have been selected to represent a maximum design scenario with respect to potential emissions (i.e., conservative estimates).

Some CMVs differ between the OCS Air Permit inventory and the General Conformity inventory. Vessels that traverse within 3 nm (3.5 mi, 5.6 km) of shoreline or within the Long Island Sound but do not enter within 25 mi (21.7 nm, 40.2 km) of OCS sources are included in the General Conformity inventory but not the OCS Air Permit inventory. An example of a CMV included in the General Conformity Inventory and not the OCS Air Permit Inventory would be vessels that travel directly from other domestic ports to staging areas.

Emissions were calculated using the methodology detailed in **Section J.4.1** and subsequent subsections.

J.5.2 Helicopters

Emissions were calculated using the methodology detailed in **Section J.4.2** and subsequent subsections.

J.5.3 Onshore Substation Facility – Stationary Diesel Generators

The onshore substation facilities associated with BW1 and BW2 are assumed to be equipped with one diesel generator engine rated at 600 kW mechanical output. The onshore substation facility generator engines are assumed to be used for both emergency and non-emergency generation. Potential emissions were estimated by conservatively assuming up to 500 operating hours per year.

Emissions were calculated using the methodology detailed in **Section J.4.3** and subsequent subsections.

J.5.4 Onshore Substation Facility – Gas-Insulated Switchgears

The onshore substation facilities associated with BW1 and BW2 will be equipped with high-voltage circuit breakers (switchgear) that use SF_6 gas as an insulating material. SF_6 is a GHG that may slowly leak from the sealed switchgear housings into the air.

Emissions of SF_6 were calculated using the methodology detailed in **Section J.4.4**.

J.5.5 Non-Road Engines

Non-road engines are used during construction of the onshore substation facility, onshore export cables, and onshore interconnection cables. Examples of equipment includes cranes, forklifts, excavators, front end loaders, generators, horizontal directional drilling (HDD) drill rigs, for this base case trenchless construction method, and other construction equipment.

Emissions factors for non-road engines for VOC, NO_X, CO, PM_{10}, $PM_{2.5}$, SO_2, HAPs, and CO_2e were determined using the EPA's Motor Vehicle Emission Simulator (MOVES3) emission factor modeling system (EPA 2021). To calculate emission factors for the Project, a run was conducted for a conservatively assumed construction start year of 2025, using the national database and inventory mode. Emission factors from the EPA's MOVES3 emission model are provided in units of grams per horsepower hour (g/hp-hr). Total emissions were estimated by the following equation:

Non-road Emissions:

E = $EF \; x \; HP \; x \; HR \; x \; LF \; x \; 1.10231E^{-6}$ [Equation 21]

Where:

E = non-road emissions per unit (tons)
EF = non-road emission factor per unit type (g/hp-hr)
HR = hours of operation
LF = load factor
$1.10231E^{-6}$ = g to ton conversion factor

Typical load factors for various equipment types were based on Appendix A of EPA's "Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling" (EPA 2010a).

J.5.6 On-Road Vehicles

MOVES3 was used to estimate emissions associated with on-road engines used during construction of the onshore substation facility, onshore export cables, and onshore interconnection cables, for a conservatively assumed construction start year of 2025. 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 grams per vehicle mile traveled [g/VMT]) for VOC, NO_X, CO, PM_{10}, $PM_{2.5}$, SO_2, HAPs, and CO_2e were calculated for 2025 using the most current database files input into MOVES3. Input values were provided by the following regional agency for the county in which the onshore construction would occur for BW1 and potentially BW2: New York State Department of Environmental Conservation for Queens County (BW1 and BW2 onshore substation facility, onshore export cables, and onshore interconnection cables). For simplicity and with the understanding of the general close proximity of the two BW2 onshore location options, the same MOVES3 factors were used when evaluating both BW2 onshore locations.

Total emissions were estimated by the following equation:

On-road Emissions:

- E = $EF \; x \; Miles \; x \; 1.10231E^{-6}$ [Equation 22]

Where:

E = on-road emissions per unit (tons)
EF = on-road emission factor per vehicle type (g/VMT)
Miles = miles driven per year
$1.10231E^{-6}$ = g to ton conversion factor

J.5.7 Construction Dust

Fugitive dust emissions will likely be generated from the onshore construction activities surrounding the onshore substation facility, onshore export cables, and onshore interconnection cables. The quantity of fugitive dust generated depends on the size of the area disturbed and the intensity of construction activity, as well as on the silt and moisture content of the soil, the wind speed, and the speed, weight, and volume of vehicular traffic. Worst-case fugitive particulate matter emissions for PM_{10} and $PM_{2.5}$ were calculated, based on EPA AP-42 (Compilation of Air Pollutant Emission Factors) recommended emission factors for heavy construction activities, along with estimates of the extent and duration of active surface disturbance. The use of the heavy construction emission factor from EPA AP-42 is meant to be general and is used to cover a wide range of construction operations. This emission factor likely overestimates potential fugitive dust generated by the proposed construction of the Project. It does not include the application of fugitive dust control measures, which would be addressed in a fugitive dust control plan prior to beginning construction.

Fugitive Dust Emissions:

- E = $EF \ x \ A \ x \ \mathrm{M}$ [Equation 23]

Where:

E = on-road emissions per unit (tons)
EF = fugitive dust factor (tons/acre/month)
A = area of land disturbed (acres/month)
M = months of construction activity

J.5.8 Decommissioning Emissions

Future decommissioning emissions were estimated by assuming they will be equivalent to 20 percent of the commissioning emissions.

J.5.9 General Conformity Emissions Summary

Air emissions associated with the combined BW1 and BW2 phases of the Project that may be subject to the General Conformity process are detailed in **Table J.5-2** and **Table J.5-3** below. **Table J.5-2** assumes BW2 is located in Queens, New York while **Table J.5-3** includes emissions assuming BW2 is located in Waterford, Connecticut. As shown in the tables below, operating emissions estimates are below general conformity thresholds.

TABLE J.5-2. GENERAL CONFORMITY EMISSIONS (BW1 AND BW2 – QUEENS, NEW YORK)

Year/Activity	General Conformity Emissions (short tons per year)											
	VOC	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e	Pb
Construction and Commissioning a/												
Hudson Valley Intrastate												
2025	---	---	---	---	0.00	---	---	---	---	---	---	---
2026	---	---	---	---	0.00	---	---	---	---	---	---	---
2027	---	---	---	---	0.00	---	---	---	---	---	---	---
2028	---	---	---	---	0.35	---	---	---	---	---	---	---
2029	---	---	---	---	0.33	---	---	---	---	---	---	---
2030	---	---	---	---	0.00	---	---	---	---	---	---	---
New Jersey-New York-Connecticut Interstate												
2025	3.01	71.25	3.96	0.08	4.66	---	---	---	---	---	---	---
2026	13.77	332.28	11.69	0.10	9.64	---	---	---	---	---	---	---
2027	36.35	899.07	48.00	0.10	19.13	---	---	---	---	---	---	---
2028	36.42	931.92	63.26	0.32	19.21	---	---	---	---	---	---	---
2029	12.02	322.51	24.95	0.26	6.77	---	---	---	---	---	---	---
2030	0.67	18.04	3.85	0.01	0.36	---	---	---	---	---	---	---
Operations and Maintenance												
Hudson Valley Intrastate												
Per Year	---	---	---	---	0.00	---	---	---	---	---	---	---
New Jersey-New York-Connecticut Interstate												
Per Year	1.03	24.62	5.46	0.01	0.51	---	---	---	---	---	---	---
Decommissioning												
Hudson Valley Intrastate												
Per Year	---	---	---	---	0.14	---	---	---	---	---	---	---
New Jersey-New York-Connecticut Interstate												
Per Year	20.34	512.53	30.59	0.17	11.90	---	---	---	---	---	---	---

Notes: a/ 2030 emissions includes operation of BW1 and commissioning of BW2

Table J.5-3. General Conformity Emissions (BW1 – Queens, New York and BW2 – Waterford, Connecticut)

Year/Activity	General Conformity Emissions (tons per year)											
	VOC	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e	Pb
Construction and Commissioning												
Hudson Valley Intrastate												
2025	---	---	---	---	0.00	---	---	---	---	---	---	---
2026	---	---	---	---	0.00	---	---	---	---	---	---	---
2027	---	---	---	---	0.00	---	---	---	---	---	---	---
2028	---	---	---	---	0.35	---	---	---	---	---	---	---
2029	---	---	---	---	0.33	---	---	---	---	---	---	---
2030	---	---	---	---	0.00	---	---	---	---	---	---	---
New Jersey-New York-Connecticut Interstate												
2025	2.47	59.21	2.90	0.05	3.43	---	---	---	---	---	---	---
2026	12.70	308.20	9.58	0.05	7.18	---	---	---	---	---	---	---
2027	29.05	724.12	40.35	0.05	14.44	---	---	---	---	---	---	---
2028	26.01	681.54	52.85	0.27	13.40	---	---	---	---	---	---	---
2029	7.08	203.34	20.27	0.24	4.48	---	---	---	---	---	---	---
2030	0.67	18.04	3.85	0.01	0.36	---	---	---	---	---	---	---
Eastern Connecticut Intrastate												
2025	0.12	2.31	---	---	---	---	---	---	---	---	---	---
2026	0.23	4.62	---	---	---	---	---	---	---	---	---	---
2027	1.05	24.05	---	---	---	---	---	---	---	---	---	---
2028	1.45	33.76	---	---	---	---	---	---	---	---	---	---
2029	0.67	15.73	---	---	---	---	---	---	---	---	---	---
2030	0.00	0.00	---	---	---	---	---	---	---	---	---	---
Operations and Maintenance												
Hudson Valley Intrastate												
Per Year	---	---	---	---	0.00	---	---	---	---	---	---	---
New Jersey-New York-Connecticut Interstate												
Per Year	0.97	24.40	4.30	0.01	0.50	---	---	---	---	---	---	---
Eastern Connecticut Intrastate												
Per Year	0.06	0.22	---	---	---	---	---	---	---	---	---	---

Year/Activity	General Conformity Emissions (tons per year)											
	VOC	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	CO_2e	Pb
Decommissioning												
Hudson Valley Intrastate												
Per Year	---	---	---	---	0.14	---	---	---	---	---	---	---
New Jersey-New York-Connecticut Interstate												
Per Year	15.49	396.40	25.41	0.14	8.61	---	---	---	---	---	---	---
Eastern Connecticut Intrastate												
Per Year	0.70	16.09	---	---	---	---	---	---	---	---	---	---

Notes:
a/ 2030 emissions includes operation of BW1 and commissioning of BW2

J.6 Total Project Emissions

Emissions that occur beyond 25 mi (21.7 nm, 40.2 km) from an OCS source and are not within a nonattainment or maintenance area are not regulated through the OCS Air Permit or General Conformity processes. However, to assess overall regional impacts to air quality from the proposed Beacon Wind Project and for BOEM's NEPA process, the emissions from the Project within the U.S. (onshore and 200 nm [230.2 mi, 370.4 km] out to sea) were estimated.

Part of the submarine export cable construction falls in this area and will primarily include CMVs traveling in attainment counties or outside state waters but still within the U.S. Also, additional pollutant emissions calculated from sources within nonattainment or maintenance counties for other pollutants is included in the total Project emissions.

Source emissions were calculated following the same methodologies detailed in **Section J.4** and **J.5** for relevant equipment.

J.6.1 Total Project Emissions Summary

Air emissions associated with the combined BW1 and BW2 phases of the Project that are subject to the OCS Air Permit are detailed in **Table J.6-1** (assuming BW2 is located in Queens, New York) and **Table J.6-2** (assuming BW2 is located in Waterford, Connecticut) below.

TABLE J.6-1. PROJECT EMISSIONS (BW1 AND BW2 – QUEENS, NEW YORK)

Year/Activity	Total BW1 and BW2 Phase Emissions (short tons per year)													
	VOC	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	AR5 100-year CO_2e	AR4100-year CO_2e	AR5 20-year CO_2e	Pb
Construction														
2025	4.92	111.27	13.47	24.83	5.46	3.42	0.78	10,000.87	0.12	0.31	10,086.15	10,095.99	10,092.51	0.000
2026	23.92	597.11	67.66	39.89	14.18	15.57	2.88	40,432.82	0.46	1.80	40,922.91	40,980.93	40,947.11	0.001
2027	414.34	10,191.18	1,085.45	208.20	171.57	268.41	48.84	599,584.09	7.91	27.16	607,002.43	607,874.94	607,418.03	0.021
2028	496.31	12,341.57	1,357.99	240.45	211.63	308.38	58.62	732,772.98	9.57	33.27	741,858.40	742,927.70	742,361.19	0.026
2029	104.89	2,738.67	342.68	57.34	51.56	54.34	12.51	177,686.26	2.11	8.15	179,905.02	180,167.65	180,014.88	0.006
2030	11.06	350.37	62.24	6.69	6.45	2.77	1.42	42,553.94	0.38	1.89	46,241.68	46,208.13	45,449.71	0.001
Total:	**1,046.23**	**26,048.67**	**2,880.97**	**571.93**	**455.58**	**650.21**	**123.84**	**1,570,307.19**	**20.21**	**71.17**	**1,589,733.28**	**1,592,021.31**	**1,590,793.63**	**0.055**
Operations and Maintenance														
Per Year	18.38	562.73	96.98	10.92	10.50	5.37	2.38	65,256.80	0.68	2.81	72,223.50	72,129.38	70,675.17	0.001
Total 35-Year Lifespan:	643.15	19,695.64	3,394.14	382.13	367.55	187.97	83.29	2,283,988.08	23.91	98.32	2,527,822.37	2,524,528.20	2,473,631.07	0.046
Decommissioning														
Total:	**209.25**	**5,209.73**	**576.19**	**114.39**	**91.12**	**130.04**	**24.77**	**314,061.44**	**4.04**	**14.23**	**317,946.66**	**318,404.26**	**318,158.73**	**0.011**

TABLE J.6-2. PROJECT EMISSIONS (BW1 – QUEENS, NEW YORK AND BW2 – WATERFORD, CONNECTICUT)

Year/Activity	Total BW1 and BW2 Phase Emissions (short tons per year)													
	VOC	NO_x	CO	PM_{10}	$PM_{2.5}$	SO_2	HAPs	CO_2	CH_4	N_2O	AR5 100-year CO_2e	AR4100-year CO_2e	AR5 20-year CO_2e	Pb
Construction														
2025	4.92	111.27	13.47	24.83	5.46	3.42	0.78	10,000.87	0.12	0.31	10,086.15	10,095.99	10,092.51	0.0002
2026	23.92	597.11	67.66	39.89	14.18	15.57	2.88	40,432.82	0.46	1.80	40,922.91	40,980.93	40,947.11	0.001
2027	414.34	10,191.18	1,085.45	208.20	171.57	268.41	48.84	599,584.09	7.91	27.16	607,002.43	607,874.94	607,418.03	0.021
2028	496.31	12,341.57	1,357.99	240.45	211.63	308.38	58.62	732,772.98	9.57	33.27	741,858.40	742,927.70	742,361.19	0.026
2029	104.89	2,738.67	342.68	57.34	51.56	54.34	12.51	177,686.26	2.11	8.15	179,905.02	180,167.65	180,014.88	0.006
2030	11.06	350.37	62.24	6.69	6.45	2.77	1.42	42,553.94	0.38	1.89	46,241.68	46,208.13	45,449.71	0.001
Total:	**1,046.23**	**26,048.67**	**2,880.97**	**571.93**	**455.58**	**650.21**	**123.84**	**1,570,307.19**	**20.21**	**71.17**	**1,589,733.28**	**1,592,021.31**	**1,590,793.63**	**0.055**
Operations and Maintenance														
Per Year	18.38	562.73	96.98	10.92	10.50	5.37	2.38	65,256.80	0.68	2.81	72,223.50	72,129.38	70,675.17	0.001
Total 35-Year Lifespan:	643.15	19,695.64	3,394.14	382.13	367.55	187.97	83.29	2,283,988.08	23.91	98.32	2,527,822.37	2,524,528.20	2,473,631.07	0.046
Decommissioning														
Total:	**209.25**	**5,209.73**	**576.19**	**114.39**	**91.12**	**130.04**	**24.77**	**314,061.44**	**4.04**	**14.23**	**317,946.66**	**318,404.26**	**318,158.73**	**0.011**

J.7 Avoided Emissions

Avoided emissions are those emissions that will be avoided by the use of wind-turbine-generated electricity verses other sources of electric power generation, particularly fossil-fuel-fired electric generating units (EGUs). Per the BOEM Wind Energy Tool V2, avoided emissions can be calculated based on the following equation.

Avoided Emissions:

- $EO_i = RP \; x \; H \; x \; CF \; x \frac{EF_{ij}}{2000}$ [Equation 24]

Where:

EOi = emissions avoided for pollutant (tons)
RP = rated power (MW)
H = total hours of Project operation
CF = capacity factor that accounts for fluctuations in wind speed
EF_{ij} = Avoided Emissions and Generation Tool (AVERT) emission factor for pollutant and region (pounds per megawatt hour [lb/MWh])
2,000 = conversion factor from lb to tons

The capacity factor used for this analysis is 44.56 percent based on NREL offshore wind conservative R&D estimates for 2024, assuming a cost recovery period of 30 years (NREL 2022)t.

AVERT emission factors were taken from Table A-3 of the BOEM Wind Energy Tool V2 Users Guide (Chang et al, 2021) and are shown in **Table J.7-1** below.

TABLE J.7-1. AVERT AVOIDED EMISSION FACTORS

AVERT Region	Emission Factors (lb/MWh)			
	CO_2	NO_x	$PM_{2.5}$	SO_2
New York	1,004	0.31	0.05	0.17
New England	1,023	0.18	0.03	0.08

Assuming 82 BW1 wind turbine locations, 73 BW2 wind turbine locations, a capacity factor of approximately 45 percent, and a 35-year lifespan of the windfarm, the amount of avoided emissions from the operation of BW1 and BW2 wind turbines are presented in **Table J.7-2** and **Table J.7-3** below. **Table J.7-2** depicts avoided emissions if BW2 is in Queens, New York and **Table J.7-3** depicts avoided emissions if BW2 is in Waterford, Connecticut.

TABLE J.7-2. AVOIDED EMISSIONS (BW1 AND BW2 – QUEENS, NEW YORK)

Time Period	Pollutant (tons)			
	CO_2	NO_x	$PM_{2.5}$	SO_2
Per Year	5,204,524.73	1,606.97	259.19	881.24
Lifespan of Project (35 years)	182,158,365.42	56,244.12	9,071.63	30,843.55

TABLE J.7-3. AVOIDED EMISSIONS (BW1 – QUEENS, NEW YORK AND BW2 – WATERFORD, CONNECTICUT)

Time Period	Pollutant (tons)			
	CO_2	NO_x	$PM_{2.5}$	SO_2
Per Year	5,250,544.52	1,292.10	210.75	663.26
Lifespan of Project (35 years)	183,769,058.23	45,223.59	7,376.17	23,213.95

J.8 References

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