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June 25, 2009

David B. Conroy
Manager, Air Programs Branch
United States Environmental Protection Agency
Region 1 Headquarters
One Congress Street, Suite 1100
Boston, MA 02114-2023

Re: Revised Vessel Emissions Estimates
Outer Continental Shelf Air Regulations Permit Application
Cape Wind Energy Project

Dear Mr. Conroy:

A Permit Application for the proposed Cape Wind Offshore Renewable Energy Project (the Project) was submitted by ESS Group, Inc. (ESS) on December 17, 2008 to fulfill the regulatory requirements of the United States Environmental Protection Agency's (EPA) Outer Continental Shelf (OCS) Air Regulations, codified under Title 40 Code of Federal Regulations, Part 55 (40 CFR § 55). The Project, as proposed by Cape Wind Associates, LLC (Cape Wind), will be located at Horseshoe Shoal, Nantucket Sound, Massachusetts, and will utilize offshore wind energy as its renewable fuel to generate electricity for sale.

A conference call was held on June 4, 2009 which included representatives from Cape Wind, EPA and the U.S. Minerals Management Service (MMS), to discuss the methodologies used by Cape Wind to estimate the emissions from vessels associated with the construction and operation of the Project for the OCS Permit and for the General Conformity Determination. At the conclusion of the June 4 conference call, EPA and MMS directed Cape Wind to revise the Project's vessel emissions estimates for the OCS Permit and for General Conformity to ensure consistency in the estimation methodology for all phases of the project, and to ensure that the most up to date and most accurate estimation techniques were employed. EPA and MMS also directed Cape Wind to consider vessel load factors in its analysis as set forth in EPA guidance documents.

At the direction of EPA and MMS, ESS has prepared revised emissions estimates for the vessels associated with the construction and operation of the Project using the EPA's "Current Methodologies in Preparing Mobile Source Port-Related Emissions Inventories – Final Report", dated April 2009 (EPA Port Study).

In accordance with Section 2.1 of the EPA Port Study, the Project vessel emissions were estimated using the following equation:

$$E = P \times LF \times A \times EF \times K$$

Where E = Emissions (tons)
P = Maximum Continuous Power Rating (kW)
LF = Load Factor (percent of vessel's total power)
A = Activity (hours)
EF = Emission Factor (grams per kilowatt-hour [g/kWh])
K = Conversion of grams to tons (g x [1 lb/454 g] x [1 ton/2000 lb])

The power ratings (P) and activity levels (A) used in the revised emissions estimates were unchanged from previous vessel emission estimates for the Project. This information represents the best estimates of the vessels and activity levels required to complete the tasks associated with each phase of the Project.

Vessel emission factors from the EPA Port Study were utilized for the revised emissions estimation for all project vessels. Table 2-2 of the study summarizes how EPA categorizes marine compression ignition engines as follows:

EPA Marine Compression Ignition Engine Categories

Category	Specification	Use	Approximate Power Ratings
1	Gross Engine Power $\geq$ 37 kW Displacement < 5 liters per cylinder	Small harbor craft and recreational propulsion	< 1,000 kW
2	Displacement $\geq$ 5 liters and < 30 liters per cylinder	Ocean going vessel (OGV) auxiliary engines, harbor craft, and smaller OGV propulsion	1,000 – 3,000 kW
3	Displacement $\geq$ 30 liters per cylinder	OGV propulsion	> 3,000 kW

All diesel powered Project vessels with a power rating less than 1,000 kW were assumed to have Category 1 engines. All diesel powered Project vessels with a power rating between 1,000 and 3,000 kW were assumed to have Category 2 engines. The associated Tier 0 engine emission factors from Table 3-8 of the EPA Port Study were used to estimate the emissions from all Project vessels with Category 1 and Category 2 engines. The Tier 0 engine emission factors were used as they represent the most conservative estimate of emissions from the vessels. The actual total emissions from the vessels with Category 1 and Category 2 engines will be lower, as some engines will be equipped with Tier 1 or Tier 2 engines, however it is unknown at this time what percentage of vessels will be equipped with such engines, so the conservative estimate seems most prudent.

All diesel powered Project vessels with a power rating greater than 3,000 kW were assumed to have Category 3 engines and to be ocean going vessels (OGV). The emission factors from Table 2-9 of the EPA Port Study for a medium-speed diesel (MSD) engine firing marine diesel oil (MDO) were used to estimate the emissions from all Project vessels with Category 3 engines. These emission factors are representative of the typical Category 3 engine vessel to be used for the Project. This represents the best available information at this time given that the actual vessels and engines to be used will not be known until contracts for the construction of the Project are executed.

The sulfur dioxide (SO_2) emission factors from the EPA Port Study were pro-rated to reflect the current EPA fuel sulfur content standard for marine diesel fuel of 500 ppm. The EPA Port Study did not contain emission factors for hazardous air pollutant (HAP) emissions from marine diesel engines. Emission factors for diesel engines from EPA's AP-42 were used to estimate the HAP emissions from the Project vessels.

The EPA Port Study defines Load Factor (LF) in Section 2.5 as follows:

$$LF = (AS/MS)^3$$

Where LF = Load Factor (percent)
AS = Actual Speed (knots)
MS = Maximum Speed (knots)

When the actual speed and/or the maximum speed of a vessel are unknown, the EPA Port Study provides guidance on the load factor to be used to estimate the emissions from a vessel, depending on its type and use. Table 3-3 of the EPA Port Study presents the recommended EPA Load Factors for Harbor Craft equipped with Category 1 and 2 engines as follows:

EPA Load Factors for Harbor Craft

Engine Category	Engine Size	Load Factor
Category 1	<805 Hp >805 Hp	0.45 0.79
Category 2	All	0.85

Consistent with the EPA Port Study, a load factor of 0.45 was assigned to all Project vessels with Category 1 engines with a power rating less than 805 Hp. A load factor of 0.79 was assigned to all Project vessels with Category 1 engines with a power rating greater than 805 Hp. A load factor of 0.85 was assigned to all project vessels with Category 2 engines.

Section 2.5 of the EPA Port Study recommends the use of a load factor of 0.83 for the propulsion of vessels with Category 3 engines at cruise speed. A load factor of 0.83 was assigned to all Project vessels with Category 3 engines with one exception. The Project involves the use of several 6,000 Hp tow tugs during its construction phase, primarily to tow barges loaded with materials and parts for construction. It has been assumed that the average cruise speed of these barges to and from the Project site will be approximately 8 knots. Table 2-6 of the EPA Port Study cites an average cruise speed for an ocean going tug to be 14.5 knots. Therefore, a load factor of 0.17 ($[8/14.5]^3$) has been assigned to the 6,000 Hp tow tugs associated with the Project in order to estimate their emissions most accurately and consistent with the practices recommended in the EPA Port Study.

Section 2.6 of the EPA Port Study states that emission factors for ocean going vessels are considered to be constant down to about 20 percent load. Below 20 percent load, emission factors tend to increase as the load decreases. Table 2-15 of the Study provides adjustment factors for each pollutant for engine operations below 20 percent. The calculated load factor for the 6,000 Hp tugs associated with the Project is 17 percent. Therefore, the emission factors for those tugs have been adjusted using the appropriate factors from Table 2-15 of the EPA Port Study to account for expected emissions increases at low load operation.

Attached is a revised version of Table 1-1 from the Project's OCS Permit Application. It summarizes the Project's revised potential emissions during preconstruction, construction, and operation from vessels in transit and from stationary sources that will occur inside 25 miles of the Project site. Table 1-1 also includes revised proposed annual emission limits for Phase 1 (preconstruction and construction) and Phase 2 (operation) of the Project. Finally, Table 1-1 summarizes the revised emission offset requirements for Phase 1 of the Project.

Also attached are revised versions of the individual spreadsheets included in Appendix A of the OCS Permit Application that were used to estimate the emissions from the Project subject to OCS permitting. These revised emission estimates for the phases of the Cape Wind Energy Project subject to OCS permitting have been done on a consistent basis, at the direction of EPA and MMS, using the most up to date EPA guidance for such estimations. If you have any questions regarding this submittal, do not hesitate to call me at (781) 489-1149.

Sincerely,

ESS GROUP, INC.

Michael E. Feinblatt
Project Manager

Attachments

C: Ida McDonnell, EPA
Karen Regas, MassDEP
Craig Olmsted, Cape Wind Associates
Rachel Pachter, Cape Wind Associates
Chris Rein, ESS
Terry Orr, ESS

Table 1-1
Cape Wind Energy Project
Project Emissions Subject to OCS Permitting - Revised June 2009

PHASE 1 - PRECONSTRUCTION & CONSTRUCTION								
Potential Emissions	Total Emissions (Tons)							
	NO_X	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPS
Preconstruction Potential Emissions - Total	13.2	0.7	0.0	4.8	0.6	0.6	766	0.0
Inside 25 Miles - Transit	13.0	0.6	0.0	4.6	0.6	0.6	725	0.0
Inside 25 Miles - Stationary Sources	0.2	0.1	0.0	0.2	0.0	0.0	41	0.0
Construction Potential Emissions - Total	164.7	7.0	1.1	24.3	6.8	6.5	9,603	0.1
Inside 25 Miles - Transit	150.1	5.4	1.1	15.7	6.3	6.0	7,871	0.1
Inside 25 Miles - Stationary Sources	14.6	1.6	0.0	8.6	0.5	0.5	1,732	0.0
Potential Emissions - Total	177.9	7.7	1.1	29.1	7.4	7.1	10,369	0.1
Inside 25 Miles - Transit	163.1	6.0	1.1	20.3	6.9	6.6	8,596	0.1
Inside 25 Miles - Stationary Sources	14.8	1.7	0.0	8.8	0.5	0.5	1,773	0.0
Proposed Annual Emission Limits	Annual Emissions (Tons Per Year)							
	NO_X	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPS
Phase 1 - Year 1 (Preconstruction + 70% Construction)	128.49	5.60	0.77	21.81	5.36	5.15	7,488	0.07
Phase 1 - Year 2 (30% Construction)	49.41	2.10	0.33	7.29	2.04	1.95	2,881	0.03
Emissions Offsets	Total ERCs (Tons Per Year)							
	NO_X	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPS
Phase 1 - Year 1 Emissions Offsets (1.26:1 Offset Ratio)	162	0	0	0	0	0	0	0
Phase 1 - Year 2 Emissions Offsets (1.26:1 Offset Ratio)	62	0	0	0	0	0	0	0

PHASE 2 - OPERATION								
Potential Emissions	Annual Emissions (Tons Per Year)							
	NO_X	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPS
Potential Emissions - Total	21.7	1.1	0.1	10.3	1.1	1.1	1,142	0.0
Inside 25 Miles - Transit	21.7	1.1	0.1	10.3	1.1	1.1	1,142	0.0
Inside 25 Miles - Stationary Sources	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0
Proposed Annual Emission Limits (Note 7)	Annual Emissions (Tons Per Year)							
	NO_X	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPS
Phase 2 - 12-month rolling total	49.9	2.5	0.2	23.7	2.5	2.5	2,626	0.0

Notes

1) Project emissions have been estimated using conservative equipment usage assumptions and EPA approved emission factors. The operating hours of all equipment used will be metered to track actual emissions.

2) The NO_X, VOC, SO_2, PM_{10}, $PM_{2.5}$ and CO_2 emissions from all vessels equipped with diesel engines subject to OCS permitting have been estimated using the appropriate emission factors and load factors from EPA's "Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report", April 2009. The HAP emissions from these vessels have been estimated using AP-42 emission factors for diesel engines.

3) The NO_X, CO, PM_{10}, and $PM_{2.5}$ emissions from all of the stationary nonroad diesel-fired engines to be used for the project have been estimated using the Tier 2 (or Tier 3 if available) emission standards from 40 CFR 89.112, Table 1 for each engine size. Additional CO and PM emissions control will be achieved through the use of diesel oxidation catalysts (DOC) on all project stationary source diesel engines.

4) The VOC, SO_2, CO_2, and HAP emissions from all of the stationary nonroad diesel-fired engines to be used for the project have been estimated using the appropriate emission factors from EPA's AP-42, "Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources". Additional VOC and HAP emissions control will be achieved through the use of DOC on all project stationary source diesel engines.

5) The SO_2 emissions from all of the diesel-fired vessel engines to be used for the project have been estimated assuming a diesel fuel sulfur content of 500 ppm, which is the current fuel sulfur content standard for all nonroad and marine diesel fuel (40 CFR 80.510(a)). All diesel stationary sources associated with the project will be fueled with ULSD (sulfur content no greater than 15 ppm) to meet the BACT requirement.

6) The emissions from the zodiac boats to be used for the project have been estimated using worst-case emission factors from the EPA document: "Exhaust Emission Factors for Nonroad Engine Modeling: Spark-Ignition", EPA420-R-05-019, Table 10.

7) The Project will be permitted for up to 49.9 tons per year of NOx emissions during Phase 2, to include a contingency for unexpected equipment maintenance and/or repair activities, while remaining a minor source of emissions. The proposed permit limits of the other pollutants have been determined by scaling their individual potential emissions by the ratio of the permitted versus potential NOx emissions.

Revised June 2009 as directed by EPA & MMS

Cape Wind Energy Project
Preconstruction Emissions Inside of 25 miles

Emission Factors from EPA's "Current Methodologies and Best Practices in Preparing Port Emission Inventories", April 2009

Diesel Fuel Sulfur Content:	500 ppm

Emission Factors - Ocean Going Vessel Main Engines, Medium-Speed Diesel, Marine Diesel Oil, g/kWh (Table 2-9)								
Engine	**NOx**	**VOC (HC)**	**SO_2**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**HAPs**
MSD & MDO	13.2	0.60	0.20	1.10	0.47	0.43	646.08	0.00635

Emission Factors - Harbor Craft, Tier 0, g/kWh (Table 3-8)								
Engine Power	**NOx**	**VOC (HC)**	**SO_2**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**HAPs**
225 - 449 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.0161
450 - 559 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.0161
560 - 999 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.00635
1,000 kW (Cat. 1)	13.0	0.27	0.043	2.50	0.30	0.29	690.00	0.00635
1,000 - 3,000 kW (Cat. 2)	13.2	0.50	0.043	1.10	0.72	0.70	690.00	0.00635

Category 1 vessels are defined by EPA as small harbor craft and recreational propulsion (<1,000 kW)
Category 2 vessels are defined by EPA as OGV auxiliary engines, harbor craft, and smaller OGV propulsion (1,000-3,000 kW)
Category 3 vessels are defined by EPA as OGV propulsion engines (>3,000 kW)
HAP emission factors are from AP-42 (Sections 3.3 & 3.4)
Ocean Going Vessel Load Factors were assumed to be 0.83, consistent with Section 2.5 of the EPA Port Emissions Guidance Document.
Harbor Craft Load Factors are from Table 3-3 of the EPA Port Emissions Guidance Document
Emissions (tons) = Engine Power Rating (kW) x Load Factor (%) x Activity (hrs) x Emission Factor (g/KWh) x (1 lb/454 g) x (1 ton/2000 lb) x (# of sources)

Diesel Fuel Sulfur Content:	15 ppm

Emission Factors (g/hp-hr) Diesel Recip. <600 hp Based on AP-42 Vol.1 , Tables 3.3-1 - 3.3-2							
NOx	**TOC**	**SO_2**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**HAPs**
	1.14	0.01				521.63	0.012

EPA Nonroad Diesel Engine Emission Standard (Tier 2 or Tier 3 if available), g/KW-hr								
Engine Size	**NOx ***	**VOC**	**SO_2**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**HAPs**
225≤kW<450	4.0			3.5	0.20	0.20		

* EPA emission standard is for NOx+NMHC. It has been assumed that all emissions are NOx to be conservative.

Emission Factors (lb/MMBtu) Natural Gas 4-Stroke Based on AP-42 Vol.1 , Table 3.2-2

NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
0.85	0.12	0.00059	0.56	0.000077	0.000077	110.00	0.072

Emission Factors (g/bhp-hr) for 50-100HP 4-stroke, outboard marine engines. Based on Exhaust Emission Factors for Nonroad Engine Modeling: Spark-Ignition. EPA420-R-05-019, Table 10. Worst case emissions factors were selected from carbureted, indirect injection and direct injection engine types. When calculating emissions, HC and PM were equated with VOC and PM10, respectively.

NOx	HC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
5.82	5.82		152.25	0.06			

Activity Type	Vessel Type/ Emission Source	Number of Sources	Equipment Size (HP)	Equipment Size (kW)	Activity	Count	Duration	Operating Hours (per unit)	Assumptions	Load Factor	Emissions (tons)							
											NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
Preconstruction Period - Activities within 25 Miles of the Project																		
Geophysical - WTG's	42' Diesel Lobster Boat	1	1,000	746	-Travel b/w Falmouth and WP - 30 miles of transect	6 days	10 hrs/day	66	- 2 hrs. @ 15 knots then 8 hrs. @ 3 knots - 10% Contingency	0.79	0.4	0.0	0.0	0.1	0.0	0.0	29.5	0.0
Geophysical - 33 kV Inner Array Cable	42' Diesel Lobster Boat	1	1,000	746	-Travel b/w Falmouth and WP - 30 miles of transect	20 days	10 hrs/day	220	- 2 hrs. @ 15 knots then 8 hrs. @ 3 knots - 10% Contingency	0.79	1.4	0.0	0.0	0.2	0.0	0.0	98.5	0.0
Geophysical - 115 kV Interconnect Cable	42' Diesel Lobster Boat	1	1,000	746	-Travel b/w Falmouth and WP - 30 miles of transect	7 days	10 hrs/day	77	- 2 hrs. @ 15 knots then 8 hrs. @ 3 knots - 10% Contingency	0.79	0.5	0.0	0.0	0.1	0.0	0.0	34.5	0.0
Electrical Generator	Gas Fired	1	8.7	6.5		30 days	10 hrs/day	300			0.008	0.001	0.000	0.005	0.000	0.000	1.007	0.001
Borings	Tug Boat	1	1,500	1,119	Travel b/w Falmouth and	30 days	24 hrs/day	720	Full Load @ 1hr/day	0.85	10.0	0.4	0.0	0.8	0.5	0.5	520.2	0.0
Boring Drill Rig	Truck mtd Rig	1	350	261	1 boring/day	20 days	10 hr/day	200	Rig Stays on HSS till done		0.2	0.1	0.0	0.2	0.0	0.0	40.2	0.0
Vibracore Boat		1	1,000	746	Final Cable Design and Constructability survey	8 days	10 hr/day	80	- 33 kV: 1 core/3 miles of cable, total 22 - 115 kV: 2 /mile of cable, total 26 - 6 /day	0.79	0.5	0.0	0.0	0.1	0.0	0.0	35.8	0.0
Multibeam Survey	26' Boat	1	300	224	Shallow area multibeam survey	8 days	10 hr/day	80		0.45	0.1	0.0	0.0	0.0	0.0	0.0	6.1	0.0
Electrical Generator	Gas Fired	1	4	3		8 days	10 hr/day	80			0.001	0.000	0.000	0.001	0.000	0.000	0.124	0.000
Crew Movement	Zodiac Boat	1	100	75	1 boring/day	20 days	10 hr/day	200	Zodiac only needed for boring program		0.1	0.1		3.4	0.001			
Preconstruction Emissions - Stationary Sources											0.2	0.1	0.0	0.2	0.0	0.0	41	0.0
Preconstruction Emissions - Transit											13.0	0.6	0.0	4.6	0.6	0.6	725	0.0
Total Preconstruction Emissions											13.3	0.7	0.0	4.8	0.6	0.6	766	0.0

All operating hours will be metered to track actual emissions.

Revised June 2009 as directed by EPA & MMS

Cape Wind Energy Project
Construction Emissions Inside of 25 miles - Transit

Note: All trips are one-way (not round trips).

Emission Factors from EPA's "Current Methodologies and Best Practices in Preparing Port Emission Inventories", April 2009

Diesel Fuel Sulfur Content:	500 ppm

Emission Factors - Ocean Going Vessel Main Engines, Medium-Speed Diesel, Marine Diesel Oil, g/kWh (Table 2-9)								
Engine	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
MSD & MDO	13.2	0.50	0.20	1.10	0.47	0.43	646.08	0.00635
Emission Factors - Harbor Craft, Tier 0, g/kWh (Table 3-8)								
Engine Power	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
225 - 449 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.0161
450 - 559 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.0161
560 - 999 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.00635
1,000 kW (Cat. 1)	13.0	0.27	0.043	2.50	0.30	0.29	690.00	0.00635
1,000 - 3,000 kW (Cat. 2	13.2	0.50	0.043	1.10	0.72	0.70	690.00	0.00635
Low Load Emissions Adjustment Factors - Ocean Going Vessels (Table 2-15)								
Load	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
0.17	1.03	1.18	1.05	1.17	1.06	1.06	1.04	1.00

Category 1 vessels are defined by EPA as small harbor craft and recreational propulsion (<1,000 kW)
Category 2 vessels are defined by EPA as OGV auxiliary engines, harbor craft, and smaller OGV propulsion (1,000-3,000 kW)
Category 3 vessels are defined by EPA as OGV propulsion engines (>3,000 kW)
HAP emission factors are from AP-42 (Sections 3.3 & 3.4)

Ocean Going Vessel Load Factors were assumed to be 0.83, consistent with Section 2.5 of the EPA Port Emissions Guidance Document. The load factor for Cat. 3 tow tugs was based on assumed speed: LF = $(AS/MS)^3$ or $(8/14.5)^3$=0.17
Harbor Craft Load Factors are from Table 3-3 of the EPA Port Emissions Guidance Document
Emissions (tons) = Engine Power Rating (kW) x Load Factor (%) x Activity (hrs) x Emission Factor (g/KWh) x (1 lb/454 g) x (1 ton/2000 lb) x (# of sources)

Activity Type	Vessel Type/ Emission Source	Number of Sources	Equipment Size (HP)	Equipment Size (kW)	Activity	Count	Duration	Operating Hours (per unit)	Assumptions	Travel Origin beyond 25 Mile Radius	Load Factor	Emissions (tons)							
												NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
Construction Period - Transit Activities within 25 Miles of the Project																			
Pile Installation																			
Move jack up barge to Wind Park	attendant tug	1	3,000	2,237	Travel b/w 25-mile boundary and WP	4 trips	4 hrs/trip	16	This is done twice (once per year)	Quonset Point, RI	0.85	0.4	0.0	0.0	0.0	0.0	0.0	23.1	0.0
Transport piles and transition pieces to wind park	tow tug	1	6,000	4,474	Travel b/w 25-mile boundary and WP	86 trips	4 hrs/trip	344	avg. 3 piles per trip, 130 piles, duration only w/in 25 miles	Quonset Point, RI	0.17	3.9	0.2	0.1	0.4	0.1	0.1	191.3	0.0
Pile barge handling tug @ Wind Park	attendant tug	1	3,000	2,237	Daily activity	130 days	4 hrs/day (load factor.33)	520	3 piles per week, attendant tugs only operate equiv of 1/2 day		0.85	14.4	0.5	0.0	1.2	0.8	0.8	751.4	0.0
Moving crew in and out	crew boats	2	750	559	daily travel b/w Falmouth and WP	130 days	2 hrs/day	260			0.45	1.4	0.0	0.0	0.2	0.0	0.0	99.4	0.0
Transition piece handling tugs @ Wind Park	attendant tug	1	3,000	2,237	Daily activity	130 days	4 hrs/day (load factor.33)	520	3 pieces per week, attendant tugs only operate equiv of 1/2 day		0.85	14.4	0.5	0.0	1.2	0.8	0.8	751.4	0.0
Installation of scour protection																			
Move scour protection installation equipment to Wind Park	attendant tug	1	3,000	2,237	Travel b/w 25-mile boundary and WP	4 trips	4 hrs/trip	16	This is done twice (once per year)	Quonset Point, RI	0.85	0.4	0.0	0.0	0.0	0.0	0.0	23.1	0.0
Transport rock armor barges	tow tug	1	6,000	4,474	Travel b/w 25-mile boundary and WP	276 trips	4 hrs/trip	1,104	Spd. 8 knts	Quonset Point, RI	0.17	12.4	0.5	0.2	1.2	0.5	0.4	613.9	0.0
Transport filler material barges	tow tug	1	6,000	4,474	Travel b/w 25-mile boundary and WP	370 trips	4 hrs/trip	1,480	Spd. 8 knts	Quonset Point, RI	0.17	16.7	0.7	0.3	1.6	0.6	0.6	823.0	0.0
Armor/filler barge handling tugs @ Wind Park	attendant tugs	2	3,000	2,237	Daily activity	130 days	4 hrs/day (load factor.33)	520			0.85	28.7	1.1	0.1	2.4	1.6	1.5	1502.8	0.0
Subtotal												92.8	3.7	0.7	8.2	4.4	4.2	4,779	0.0
Cable laying																			
115 kV Cable laying barge to wind farm	tow tug	1	1,500	1,119	Travel b/w 25-mile boundary and WP	4 trips	4 hrs/trip	16		Quonset Point, RI	0.79	0.2	0.0	0.0	0.0	0.0	0.0	10.7	0.0
Put cable in place	crane barge	1	400	298		15 days	10 hrs/day	150	10 hrs/day for 15 work days		0.45	0.2	0.0	0.0	0.0	0.0	0.0	15.3	0.0
Put cable in place	attendant tug	1	1,500	1,119		15 days	10 hrs/day	150	10 hrs/day for 15 work days		0.79	1.9	0.0	0.0	0.4	0.0	0.0	100.7	0.0
Put cable in place	anchoring tug	1	4,000	2,983		15 days	10 hrs/day	150	10 hrs/day for 15 work days		0.85	5.5	0.2	0.0	0.5	0.3	0.3	289.0	0.0
Moving crew in and out	crew boats	1	750	559		15 days	2 hrs/day	30			0.45	0.1	0.0	0.0	0.0	0.0	0.0	5.7	0.0
33 kV Cable laying barge to wind farm	tow tug	1	1,500	1,119	Travel b/w 25-mile boundary and WP	26 trips	4 hrs/trip	104	13 round trips	Quonset Point, RI	0.79	1.3	0.0	0.0	0.3	0.0	0.0	69.8	0.0

Revised June 2009 as directed by EPA & MMS

Cape Wind Energy Project
Construction Emissions Inside of 25 miles - Transit

Note: All trips are one-way (not round trips).

Emission Factors from EPA's "Current Methodologies and Best Practices in Preparing Port Emission Inventories", April 2009

Emission Factors - Ocean Going Vessel Main Engines, Medium-Speed Diesel, Marine Diesel Oil, g/kWh (Table 2-9)								
Engine	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
MSD & MDO	13.2	0.50	0.20	1.10	0.47	0.43	646.08	0.00635
Emission Factors - Harbor Craft, Tier 0, g/kWh (Table 3-8)								
Engine Power	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
225 - 449 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.0161
450 - 559 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.0161
560 - 999 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.00635
1,000 kW (Cat. 1)	13.0	0.27	0.043	2.50	0.30	0.29	690.00	0.00635
1,000 - 3,000 kW (Cat. 2	13.2	0.50	0.043	1.10	0.72	0.70	690.00	0.00635
Low Load Emissions Adjustment Factors - Ocean Going Vessels (Table 2-15)								
Load	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
0.17	1.03	1.18	1.05	1.17	1.06	1.06	1.04	1.00

Diesel Fuel Sulfur Content: 500 ppm

Category 1 vessels are defined by EPA as small harbor craft and recreational propulsion (<1,000 kW)
Category 2 vessels are defined by EPA as OGV auxiliary engines, harbor craft, and smaller OGV propulsion (1,000-3,000 kW)
Category 3 vessels are defined by EPA as OGV propulsion engines (>3,000 kW)
HAP emission factors are from AP-42 (Sections 3.3 & 3.4)

Ocean Going Vessel Load Factors were assumed to be 0.83, consistent with Section 2.5 of the EPA Port Emissions Guidance Document. The load factor for Cat. 3 tow tugs was based on assumed speed: LF = $(AS/MS)^3$ or $(8/14.5)^3$=0.17
Harbor Craft Load Factors are from Table 3-3 of the EPA Port Emissions Guidance Document
Emissions (tons) = Engine Power Rating (kW) x Load Factor (%) x Activity (hrs) x Emission Factor (g/KWh) x (1 lb/454 g) x (1 ton/2000 lb) x (# of sources)

Activity Type	Vessel Type/ Emission Source	Number of Sources	Equipment Size (HP)	Equipment Size (kW)	Activity	Count	Duration	Operating Hours (per unit)	Assumptions	Travel Origin beyond 25 Mile Radius	Load Factor	Emissions (tons)							
												NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
Put cable in place	crane barge	1	400	298		130 days	10 hrs/day	1300	10 hrs/day for 10 work days/string - 13 strings		0.45	1.9	0.1	0.0	0.3	0.1	0.1	132.6	0.0
Put cable in place	attendant tug	1	1,500	1,119		130 days	10 hrs/day	1300	10 hrs/day for 10 work days/string - 13 strings		0.79	16.4	0.3	0.1	3.2	0.4	0.4	872.9	0.0
Move Crane barge to cofferdam location	tow tug	1	1,500	1,119	Travel b/w 25-mile boundary and WP	4 trips	3 hrs/trip	12		Quonset Point, RI	0.79	0.2	0.0	0.0	0.0	0.0	0.0	8.1	0.0
HDD Cofferdam Excavation	crane barge	1	400	298	Excavation	2 days	10 hrs/day	20	2 day @10 hrs/day - Spd. ~ 12 knts		0.45	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Moving crew in and out	crew boat	1	750	559		10 days	2 hrs/day	20	1hr each way per crew boat		0.45	0.1	0.0	0.0	0.0	0.0	0.0	3.8	0.0
Subtotal												**27.9**	**0.7**	**0.1**	**4.7**	**0.8**	**0.8**	**1,511**	**0.0**
Turbine Installation																			
Turbines to Wind Farm	one specialized vessel	1	6,000	4,474	Travel b/w 25-mile boundary and WP	86 trips	4 hrs./trip	344	Only emissions within 25 miles of Wind Park	Quonset Point, RI	0.83	18.6	0.7	0.3	1.5	0.7	0.6	909.0	0.0
Moving crew in and out	crew boats	4	750	559		130 days	2 hrs/day	260	2 days per WTG		0.45	2.9	0.1	0.0	0.4	0.1	0.1	198.9	0.0
Subtotal												**21.5**	**0.8**	**0.3**	**2.0**	**0.7**	**0.7**	**1,108**	**0.0**
ESP Installation																			
Crane barge towing	tow tug	1	3,000	2,237	Travel b/w 25-mile boundary and WP	2 trips	12 hrs/trip	24	12 hrs. out, 12 hours back	Quonset Point, RI	0.85	0.7	0.0	0.0	0.1	0.0	0.0	34.7	0.0
Handling crane barge	attendant tug	1	3,000	2,237		1	16 hrs.	20	4 hrs. transit and 16 hrs. on site		0.85	0.6	0.0	0.0	0.0	0.0	0.0	28.9	0.0
Pile Installation barge towing	tow tug	1	3,000	2,237	Travel b/w 25-mile boundary and WP	2 trips	9 hrs/trip	18	12 hrs. out, 6 hours back	Quonset Point, RI	0.85	0.5	0.0	0.0	0.0	0.0	0.0	26.0	0.0
Handling barge	attendant tug	1	3,000	2,237		6	3 hrs.	18			0.85	0.5	0.0	0.0	0.0	0.0	0.0	26.0	0.0
ESP deck to wind farm	tow tug	1	6,000	4,474	Travel b/w 25-mile boundary and WP	2 trips	9 hrs/trip	18	12 hrs. out, 6 hours back	Quonset Point, RI	0.17	0.2	0.0	0.0	0.0	0.0	0.0	10.0	0.0
Crane barge towing	tow tug	1	3,000	2,237	Travel b/w 25-mile boundary and WP	2 trips	12 hrs/trip	24	12 hrs. out, 12 hours back	Quonset Point, RI	0.85	0.7	0.0	0.0	0.1	0.0	0.0	34.7	0.0
Setting the deck for ESP installation	crane barge	1	6,000	4,474		1	16 hrs.	16			0.83	0.9	0.0	0.0	0.1	0.0	0.0	42.3	0.0
Handling crane barge	attendant tug	1	3,000	2,237		2 trips	9 hrs/trip	18	12 hrs. out, 6 hours back		0.85	0.5	0.0	0.0	0.0	0.0	0.0	26.0	0.0
Moving crew in and out	crew boats	4	750	559		160 trips	2 hrs/trip	320	40 days, 2 RT/day - 2 hrs.each way		0.45	3.5	0.1	0.0	0.5	0.1	0.1	244.8	0.0
Subtotal												**8.0**	**0.3**	**0.0**	**0.9**	**0.3**	**0.3**	**473**	**0.0**
TOTAL Construction Emissions Over 1 to 2-Year Construction Duration												**150.1**	**5.4**	**1.1**	**15.7**	**6.3**	**6.0**	**7,871**	**0.1**

All operating hours will be metered to track actual emissions.

Revised June 2009 as directed by EPA & MMS

Note: All trips are one-way (not round trips).

Cape Wind Energy Project
Construction Emissions Inside of 25 miles - Stationary Activities

Emission Factors (g/hp-hr)Diesel Recip. >600 hp Based on AP-42 Vol.1 , Tables 3.4-1 - 3.4-4							
NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
	0.33	0.01				526.16	0.00474

Diesel Fuel Sulfur Content:	15 ppm

Emission Factors (g/hp-hr) Diesel Recip. <600 hp Based on AP-42 Vol.1 , Tables 3.3-1 - 3.3-2							
NOx	TOC*	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
	1.14	0.01				521.63	0.012

* Emission factor for VOC was not available; TOC emission factor is used instead, which will result in a very conservative estimation of VOC emissions.

EPA Nonroad Diesel Engine Emission Standard (Tier 2 or Tier 3 if available), g/KW-hr								
Engine Size	NOx *	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
75≤kW<130	4.0			5.0	0.30	0.30		
225≤kW<450	4.0			3.5	0.20	0.20		
kW>560	6.4			3.5	0.20	0.20		

* EPA emission standard is for NOx+NMHC. It has been assumed that all emissions are NOx to be conservative.

Activity Type	Vessel Type/ Emission Source	Number of Sources	Equipment Size (HP)	Equipment Size (kW)	Activity	Count	Duration	Operating Hours (per unit)	Assumptions	Emissions (tons)							
										NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
Construction Period - Stationary Activities within 25 Miles of the Project																	
Pile Installation																	
Put piles in place	primary 500 ton crane	1	800	597	Set piles	130 days	4 hrs/day	520		2.2	0.2	0.0	1.2	0.1	0.1	241.1	0.0
Pile driving	Hydraulic ram	1	1,600	1,193	Set piles	130 piles	4 hrs/pile	520	IHC S-1200 hydrohammer	4.4	0.3	0.0	2.4	0.1	0.1	482.1	0.0
Set transition pieces	primary 500 ton crane	1	800	597	Set Pieces	130 days	4 hrs/day	520		2.2	0.2	0.0	1.2	0.1	0.1	241.1	0.0
Installation of scour protection																0.0	0.0
Install rock armor	crane	1	400	298	Daily activity	65 days	8 hrs/day	520	2 towers per day	0.7	0.3	0.0	0.6	0.0	0.0	119.5	0.0
Install filler material	crane	1	400	298	Daily activity	65 days	8 hrs/day	520	2 towers per day	0.7	0.3	0.0	0.6	0.0	0.0	119.5	0.0
Subtotal										**10.1**	**1.1**	**0.0**	**6.0**	**0.3**	**0.3**	**1,203**	**0.0**
Cable laying																	
Sheet Pile Driving for cofferdam		1	400	298		2 days	10 hrs/day	20	2 day @10 hrs/day	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0
Compressor Drive		1	100	75		2 days	8 hrs/day	16	2 day @8 hrs/day	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0
Sheet Pile Removal		1	400	298		2 days	10 hrs/day	20	2 day @10 hrs/day	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0
Cofferdam Backfill	crane barge	1	400	298	Backfill	2 days	10 hrs/day	20	2 day @10 hrs/day	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0
Subtotal										**0.1**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**15**	**0.0**
Turbine Installation																	
Stabilizing the the WTG vessel in correct location and elevation	jacking system with 6 legs	1	476	355		130 days	2 hrs/day	260		0.4	0.2	0.0	0.4	0.0	0.0	71.1	0.0
Tower Installation	primary 500 ton crane	1	800	597		130 days	2 hrs/day	260		1.1	0.1	0.0	0.6	0.0	0.0	120.5	0.0
Nacelle installation	primary 500 ton crane	1	800	597		130 days	2 hrs/day	260		1.1	0.1	0.0	0.6	0.0	0.0	120.5	0.0
Rotor installation	primary 500 ton crane	1	800	597		130 days	2 hrs/day	260		1.1	0.1	0.0	0.6	0.0	0.0	120.5	0.0
Subtotal										**3.7**	**0.4**	**0.0**	**2.1**	**0.1**	**0.1**	**433**	**0.0**
ESP Installation																	
Setting template for ESP installation	crane	1	3,000	2,237		1	16 hrs.	16		0.3	0.0	0.0	0.1	0.0	0.0	27.8	0.0
Pile setting	crane	1	3,000	2,237		6	3 hrs.	18		0.3	0.0	0.0	0.2	0.0	0.0	31.3	0.0
Pile driving	Hydraulic ram	1	3,200	2,386		6	2 hrs.	12	IHC S-500 hydrohammer	0.2	0.0	0.0	0.1	0.0	0.0	22.3	0.0
Subtotal										**0.7**	**0.1**	**0.0**	**0.4**	**0.0**	**0.0**	**81**	**0.0**
TOTAL Construction Emissions Over 1 to 2-Year Construction Duration										**14.6**	**1.6**	**0.0**	**8.6**	**0.5**	**0.5**	**1,732**	**0.0**

All operating hours will be metered to track actual emissions.

Revised June 2009 as directed by EPA & MMS

Note: All trips are one-way (not round trips).

Cape Wind Energy Project
Operation Emissions Inside of 25 miles

Emission Factors from EPA's "Current Methodologies and Best Practices in Preparing Port Emission Inventories", April 2009

Diesel Fuel Sulfur Content:	500 ppm

Emission Factors - Ocean Going Vessel Main Engines, Medium-Speed Diesel, Marine Diesel Oil, g/kWh (Table 2-9)								
Engine	**NOx**	**VOC (HC)**	**SO_2**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**HAPs**
MSD & MDO	13.2	0.50	0.20	1.10	0.47	0.43	646.08	0.00635
Emission Factors - Harbor Craft, Tier 0, g/kWh (Table 3-8)								
Engine Power	**NOx**	**VOC (HC)**	**SO_2**	**CO**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**HAPs**
225 - 449 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.0161
450 - 559 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.0161
560 - 999 kW (Cat. 1)	10.0	0.27	0.043	1.50	0.30	0.29	690.00	0.00635
1,000 kW (Cat. 1)	13.0	0.27	0.043	2.50	0.30	0.29	690.00	0.00635
1,000 - 3,000 kW (Cat. 2	13.2	0.50	0.043	1.10	0.72	0.70	690.00	0.00635

Category 1 vessels are defined by EPA as small harbor craft and recreational propulsion (<1,000 kW)
Category 2 vessels are defined by EPA as OGV auxiliary engines, harbor craft, and smaller OGV propulsion (1,000-3,000 kW)
Category 3 vessels are defined by EPA as OGV propulsion engines (>3,000 kW)
HAP emission factors are from AP-42 (Sections 3.3 & 3.4)
Ocean Going Vessel Load Factors were assumed to be 0.83, consistent with Section 2.5 of the EPA Port Emissions Guidance Document.
Harbor Craft Load Factors are from Table 3-3 of the EPA Port Emissions Guidance Document
Emissions (tons) = Engine Power Rating (kW) x Load Factor (%) x Activity (hrs) x Emission Factor (g/KWh) x (1 lb/454 g) x (1 ton/2000 lb) x (# of sources)

Outboard Emission Factors (g/bhp-hr) for 50-100HP 4-stroke, outboard engines. Based on Exhaust Emission Factors for Nonroad Engine Modeling: Spark-Ignition. EPA420-R-05-019, Table 10. Worst case emissions factors were selected from carbureted, indirect injection and direct injection engine types. When calculating emissions, HC and PM were equated with VOC and PM10, respectively.

HC	Nox	SO_2	CO	PM	$PM_{2.5}$	CO_2	HAPs
5.82	5.82		152.25	0.06			

Activity Type	Vessel Type/ Emission Source	Number of Sources	Equipment Size (HP)	Equipment Size (kW)	Activity	Count	Duration	Operating Hours (per unit)	Assumptions	Load Factor	Emissions (tons)							
											NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
Maintenance - per year																		
Crew transport	Crew boats	1	750	559	Travel b/w Falmouth and WP	504 trips	1 hr/trip	504	avg. 1 trips/day X 252 days	0.45	1.4	0.0	0.0	0.2	0.0	0.0	96.4	0.0
Support vessel	Maintenance vessels	1	1,500	1,119	Travel b/w Falmouth and WP	504 trips	1 hr/trip	504	avg. 1 trips/day X 252 days	0.85	7.0	0.3	0.0	0.6	0.4	0.4	364.1	0.0
Special duty supply vessel	Maintenance vessel	1	3,000	2,237	Travel b/w New Bedford and WP	48 trips	5 hrs/trip	230	Required irregularly - assume 2 rund trips per month	0.85	6.4	0.2	0.0	0.5	0.3	0.3	332.6	0.0
Support vessel	Maintenance vessels	1	1,500	1,119	Travel b/w New Bedford and WP	504 trips	1 hr/trip	483	avg. 1 trips/day X 252 days	0.85	6.7	0.3	0.0	0.6	0.4	0.4	349.2	0.0
Crew Movement	Zodiac Boat	1	100	75	Daily activity	504 trips	1 hr/trip	504	avg. 1 trips/day X 252 days		0.3	0.3		8.5	0.003			
Sub-Total											**21.7**	**1.1**	**0.1**	**10.3**	**1.1**	**1.1**	**1,142**	**0.0**
Total Annual Operation Emissions (tons per year)											**21.7**	**1.1**	**0.1**	**10.3**	**1.1**	**1.1**	**1,142**	**0.0**

Note: Hours were prorated based on the following assumptions:
- New Bedford to 25-mile Radius Border = 2.2 Miles
- New Bedford to Wind Park = 53.8 Miles
- Miles are nautical milles

All operating hours will be metered to track actual emissions.

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