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March 12, 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: 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 (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.

The EPA Region I Air Programs Branch issued a comment letter on the Cape Wind OCS Permit Application to ESS on February 10, 2009. The following are responses to the specific comments contained in the letter, which have been prepared by ESS on behalf of Cape Wind:

Comment #1: Provide a more comprehensive top-down BACT analysis and LAER analysis.

Response #1: As requested by EPA, a more comprehensive top-down BACT analysis has been conducted for the stationary sources associated with the Project. These stationary sources include boring drill rigs, cranes, hydraulic rams, pile drivers, and jacking systems. The BACT analysis conducted included identifying all potential control technologies for each pollutant, eliminating technically infeasible control options, ranking remaining control technologies in order of effectiveness, and selecting BACT. A more comprehensive LAER analysis for NO_X has also been conducted for the Project stationary sources. This analysis involved identifying previous permit limits and LAER determinations for similar sources from other projects.

Guidance documents on controlling emissions from diesel construction equipment from the EPA, Massachusetts Department of Environmental Protection (MassDEP), the California Air Resource Board (CARB), the South Coast Air Quality Management District (SCAQMD), and other sources were referenced for this analysis. The MassDEP's "Diesel Engine Retrofits in the Construction Industry", January 2008, provided information on Massachusetts state agency construction retrofit requirements, available diesel engine retrofit technologies, case studies (including Boston's "Big Dig" Central Artery Construction Project), and a listing of currently verified diesel engine retrofit technologies. The EPA (http://www.epa.gov/otaq/retrofit/verif-list.htm) and CARB (http://www.arb.ca.gov/diesel/verdev/verifiedtechnologies/cvt.htm) verified technologies lists were also referenced for this analysis. These lists include diesel retrofit technologies that EPA and CARB have approved for use in engine retrofit programs and the percent reduction that they will recognize for emission reductions for each technology. Information from the EPA's RACT/BACT/LAER Clearinghouse (RBLC) was also used during the completion of this analysis.

Please see Attachment A, Cape Wind Energy Project Construction Equipment BACT/LAER Analysis, which summarizes the findings of the analysis conducted for the Project's stationary sources. The following is a brief description of the BACT/LAER determinations for the Project.

Nitrogen Oxides (NO_X) BACT/LAER Determination

There are several add-on NO_X control technologies that have been developed for potential use on diesel construction equipment. These technologies are NO_X adsorbers, selective catalytic reduction (SCR), exhaust gas recirculation (EGR), and lean NO_X or NO_X reducing catalyst (NRC) systems. These systems can provide 25-90% NO_X emissions control for diesel engines.

These systems are proven emissions control technologies for stationary diesel engines that provide emergency or auxiliary power and that, when needed, operate consistently at a high, stable load. However, they are all complex systems, with significant installation and maintenance costs, that are not considered to be viable retrofit technologies for sources with transient and highly variable operating characteristics.

According to the MassDEP construction industry retrofit guide, none of the identified Massachusetts state agencies requires add-on controls for NO_X emissions in their procurement requirements, nor were add-on NO_X emissions controls used on construction equipment in any of the case studies presented, including the Big Dig. The EPA and CARB verified technologies lists do not indicate a verified NO_X emissions control system for any stationary sources similar to the ones proposed for the Cape Wind Project. In its In-Use Off-Road Diesel Vehicle Regulation, CARB does not require add-on NO_X emission controls for diesel engines; it requires the retirement of old engines and replacement with newer engines that are certified to meet stricter EPA emission standards by design.

There are no add-on NO_X control technologies that are considered to be technically feasible control options for the Project's stationary sources, based on precedent and available state and federal technical guidance. BACT for NO_X for construction equipment is achieved through the use of newer engine models that are certified by their manufacturer to meet the more stringent Tier 2 and Tier 3 EPA emission standards.

A search of the RBLC database did not identify any previous permits or LAER determinations for specific emission sources similar to those proposed for the Project. A LAER determination for a source typically requires a manufacturer's guarantee and verification of the proposed emission rate through emissions testing. Compliance with the EPA NO_X emission standards for the source types proposed for the Project is required to be demonstrated through a certification from the manufacturer of compliance with the required Tier 1, Tier 2, or Tier 3 emission standards for the specific engine size and model year. Manufacturers of the equipment types proposed for the Project will not provide an emissions guarantee beyond compliance with the already promulgated EPA standards; nor is there a reliable methodology for a demonstration of compliance with an emission guarantee lower than the EPA standards.

The NO_X BACT/LAER determination for the Project is the use of newer engines that are certified to meet the EPA's Tier 2 and Tier 3 emission standards. The attached Table 1 from 40 CFR 89 summarizes the EPA's emission standards for diesel nonroad engines for each engine size and model year. Cape Wind will require through its specification and procurement process that its contractors and subcontractors commit to the use of stationary source diesel equipment with engines that meet the strictest EPA emission standard for NO_X that is commercially available for that application. In no case will an engine be used on the Project that is not certified to meet its respective EPA Tier 2 or Tier 3 NO_X emission standard, if equipment with such an engine is commercially available for that application.

Particulate Matter ($PM/PM_{10}/PM_{2.5}$), Carbon Monoxide (CO), Volatile Organic Compound (VOC), Hazardous Air Pollutant (HAP) BACT Determinations

There are several add-on control technologies that have been developed for potential use on diesel construction equipment that can provide PM, CO, VOC, and HAP emissions control. These technologies are active diesel particulate filters (DPF), catalyzed diesel particulate filters (CDPF), flow-through filters (FTF), and diesel oxidation catalysts (DOC). These technologies can provide 20-90% control for PM, CO, VOC, and HAP emissions from diesel engines.

These systems are proven emissions control technologies for stationary diesel engines installed at facilities to provide emergency or auxiliary power that when needed, operate consistently at a high, stable load. DPF, CDPF, and FTF can increase fuel usage and back-pressure on an engine, and require a minimum exhaust temperature to be maintained at all times for efficient operation. The need for engine pressure and temperature monitoring and the minimum exhaust temperature requirement makes these technologies more suited for engines at stationary installations that operate at high, steady-state loads for extended periods of time.

The stationary sources associated with the Cape Wind Project utilize engines whose operation will be transient and highly variable depending on the task at hand and localized operating conditions on Horseshoe Shoal. These variable conditions are not conducive to the efficient use of DPF, CDPF, or FTF for the control of emissions. The EPA and CARB verified technologies lists do not indicate verified DPF, CDPF, or FTF emission control systems for the stationary source types proposed for the Project. A search of the RBLC database did not identify any permits for the use of such emissions control systems on similar sources as those proposed for the Project. Therefore these technologies are not considered to be technically feasible emissions control options for the Project.

The use of DOC for PM/CO/VOC/HAP emissions control is a proven technology for diesel construction equipment. A DOC can be used on almost any construction diesel engine and can provide PM emissions control of up to 33%, and CO/VOC/HAP emissions control of up to 75%. The installation of a DOC on a diesel engine is generally straightforward and they require virtually no ongoing maintenance after installation. They have been installed on thousands of construction equipment engines throughout the United States.

According to the MassDEP construction industry retrofit guide, the use of DOC would meet the emissions control requirements for construction equipment for the identified Massachusetts state agencies in their procurement requirements. DOC was also the emissions control technology most commonly utilized for construction equipment in the case studies presented in the guide, including for the Big Dig.

DOC is considered to be the only technically feasible add-on emissions control system for the Project's stationary sources. The $PM/PM_{10}/PM_{2.5}/CO/VOC/HAP$ BACT determination for the Project is the use of DOC on all stationary sources equipped with diesel engines for which a DOC retrofit is technically viable, and the use of engines that are certified to meet the EPA's Tier 2 and Tier 3 emission standards. The attached Table 1 from 40 CFR 89 summarizes the EPA's emission standards for diesel nonroad engines for each engine size and model year. Cape Wind will require through its specification and procurement process that its contractors and subcontractors use only stationary source diesel engines that are equipped with DOC emission control systems (when a DOC retrofit is technically viable) and that meet the strictest EPA emission standards that are commercially available for that application. In no case will an engine be used that is not certified to meet its respective EPA Tier 2 or Tier 3 emission standards, if equipment with such an engine is commercially available for that application.

Sulfur Dioxide (SO_2) BACT Determination

There are no add-on control technologies currently available for diesel engines for SO_2. Diesel engine emission reductions for SO_2 are achieved by the use of low sulfur content fuels. According to 40 CFR 80.510, beginning June 1, 2007, all nonroad diesel fuel became subject to a sulfur content limitation of 500 parts per million (ppm). Beginning June 1, 2010, all nonroad diesel fuel will become subject to a sulfur content limitation of 15 ppm.

Cape Wind will require through its specification and procurement process that its contractors and subcontractors use ultra low sulfur diesel (ULSD) fuel with a sulfur content no greater than 15 ppm for all of the stationary source diesel engines utilized for the Project. The use of ULSD will result in the lowest SO_2 emission rates technically feasible for these engines, and is therefore the SO_2 BACT determination for the Project.

Comment #2: Based on the BACT/LAER analyses, propose specific annual limits that reflect the potential emissions of the project for each year of Phases 1 and 2.

Response #2: Attached is a revised version of Table 1-1 from the application, which summarizes the total potential emissions from the Project during Phase 1, and the potential annual emissions from the Project during Phase 2. Also attached are revised Appendix A emissions calculation summaries, which utilize emission rates for the Project's stationary sources that are consistent with the revised BACT/LAER determinations.

The total duration of Phase 1 will be one to two years, depending on the availability of equipment and materials, as well as meteorological conditions during construction activities. For the purposes of determining an annual emissions limit during Phase 1, it has been assumed that the preconstruction emissions and 50% of the construction emissions occur during the first year, while 50% of the construction emissions occur during the second year.

Table 1-1 summarizes the Project's potential annual emission during Phase 2. In order to provide contingency for unscheduled maintenance and repair activities, Cape Wind is requesting that the Project be permitted for up to 49.9 tons of NO_X per year during Phase 2. The proposed annual emission limits for each of the other pollutants has been determined as the annual potential emissions of that pollutant scaled by the ratio of the permitted annual NO_X emissions to the potential annual NO_X emissions for consistency.

Table 1-1 lists the proposed annual emission limits for each year during Phases 1 and 2 of the Project. Cape Wind will record fuel usage and/or operating hours of all vessels and equipment used on the Project during Phases 1 and 2, to track compliance with the permitted annual emission limits.

Comment #3: Clarify and confirm the plans for the crane to be located on the ESP.

Response #3: Since the filing of the application, Cape Wind has made the determination that there will not be a need for a crane on the ESP during the operational period (Phase 2). If a crane is required during this period, it will be electrically powered, and not be a source of air emissions. There will be no stationary emission sources installed at the Cape Wind facility during Phase 2.

Comment #4: Calculate project vessel emissions using emission factors from the reference document "Current Methodologies and Best Practices in Preparing Port Emission Inventories", January 2006.

Response #4: The NO_X, VOC, SO_2, CO, PM_{10}, and $PM_{2.5}$ emissions from all Project vessels equipped with diesel engines subject to OCS permitting have been revised, and estimated using the appropriate emission factors from the referenced EPA guidance document. The guidance document does not include CO_2 or HAP emission factors for vessels, thus the CO_2 and HAP emissions from the Project vessels have been estimated using AP-42 emission factors for diesel engines and remain unchanged from the original application.

The attached revised versions of Table 1-1 and the Appendix A emissions calculation summaries reflect the use of vessel emission factors from the referenced EPA guidance document.

Comment #5: Clarify the units of the diesel engine HAP emission factors used in the application.

Response #5: The HAP emission factors used for diesel engines in the application were determined using emission factors from AP-42, Tables 3.3-2 (less than 600 Hp), 3.4-3 and 3.4-4 (greater than 600 Hp). The individual HAP emission factors for diesel engines in the referenced AP-42 tables are in the units of lb/MMBtu.

In order to estimate the total HAP emissions for the diesel engines to be used on the Project, the individual HAP lb/MMBtu emission factors were converted to g/hp-hr emission factors using standard conversion factors, and assuming an average brake-specific fuel consumption (BSFC) of 7,000 Btu/hp-hr, per AP-42 guidance. The individual g/hp-hr HAP emission factors were then added together to determine a total HAP g/hp-hr emission factor for each engine category. The HAP emission factors were also determined on a gram per kilowatt-hour (g/kW-hr) basis using a standard conversion factor.

The attached HAP emission factor calculation sheet lists the lb/MMBtu AP-42 emission factors, the converted g/hp-hr and g/kW-hr emission factors, and the equations used to estimate the HAP emissions from the diesel engines to be used on the Project.

I hope that the preceding responses have adequately addressed the concerns raised in your comment letter. If you have any questions regarding these comment responses, 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

NOx

Control Technology	Emissions Reduction	Retrofit Cost	On-going Maintenance	Benefit	Down Side	Implementation Issues	BACT Determination
NOx Adsorbers	>90%	Extremely high	Extremely high	High overall NOx emission reductions	Increases fuel usage; releases sulfur compounds	At this time, engine integration issues are highly complex;	Not verified to be technically feasible for project source types
Selective Catalytic Reduction (SCR)	70 - 90%	$20,000 - $40,000 for a 250 Hp engine	Very High	Can significantly reduce NOx emissions and offer some modest PM reductions	Can create excess ammonia emissions; adds significant equipment costs and maintenance issues	Requires the use of a urea reductant; use in construction equipment with transient engine operation considered too complicated	Not verified to be technically feasible for project source types
Exhaust Gas Recirculation (EGR)	30 - 50%	High	High	Can significantly reduce NOx emissions from diesel engines	Adds significant equipment, increasing potential for failures and maintenance costs	Not a viable retrofit technology; must be engineered into new engine designs	Not verified to be technically feasible for project source types
Lean NOx Catalyst (NRC)	25 - 35%	$15,000 - $30,000 for a 250 Hp engine	High	Can reduce NOx emissions, and also offers CO, HC, and PM reductions when coupled with a DPF	Adds significant equipment, increasing potential for failures and maintenance costs; 5-10% fuel penalty;	Systems are complicated; no NRC systems have been verified by the EPA	Not verified to be technically feasible for project source types
BACT/LAER Determination:	There are no add-on control technologies for NOx that have been verified by the EPA or CARB that are technically feasible for the source types to be utilized for the project. BACT/LAER for NOx will be the use of engines that are certified by their manufacturer to meet the strictest EPA NOx emission standards for diesel engines that are commercially available for each project use.						

$PM/PM_{10}/PM_{2.5}$

Control Technology	Emissions Reduction	Retrofit Cost	On-going Maintenance	Benefit	Down Side	Implementation Issues	BACT Determination
Active Diesel Particulate Filter (DPF)	60 - 90%	$14,000 - $20,000 for a 250 Hp engine	Annual filter cleaning ($200-300/year)	Significantly reduce CO, HC and PM emissions	Can significantly increase back-pressure on the engine; must be monitored to avoid engine failure; modest fuel penalty	Can be used on almost any engine; complicated system with high installation costs	Not verified to be technically feasible for project source types
Catalyzed Diesel Particulate Filter (CDPF)	60 - 90%	$5,000-$7,000 for a 250 Hp engine	Annual filter cleaning ($200-300/year)	Significantly reduce CO, HC and PM emissions	Can significantly increase back-pressure on the engine; must be monitored to avoid engine failure	Exhaust temperature requirements make use with lightly loaded duty cycles not appropriate for use	Not verified to be technically feasible for project source types
Flow-Through Filter (FTF)	50%	$3,500-$5,000 for a 250 Hp engine	None	Significantly reduce CO, HC and PM emissions	Application limited to high duty cycles; slight fuel penalty	May require additional mounting hardware; space constraints on some equipment; requires a minimum exhaust temperature	Not verified to be technically feasible for project source types
Diesel Oxidation Catalyst (DOC)	20 - 33%	$300 - $1,500 for a 250 Hp engine	None	Significantly reduce CO, HC and reduce PM emissions	Few operational issues with proper design	Must fit within existing exhaust piping configuration and engine compartment	BACT
BACT Determination:	DOC is the only add-on control technology for PM that has been verified by the EPA and CARB that is technically feasible for the source types to be utilized for the project.						

CO, VOC, HAP

Control Technology	Emissions Reduction	Retrofit Cost	On-going Maintenance	Benefit	Down Side	Implementation Issues	BACT Determination
Active Diesel Particulate Filter (DPF)	60 - 90%	$14,000 - $20,000 for a 250 Hp engine	Annual filter cleaning ($200-300/year)	Significantly reduce CO, HC and PM emissions	Can significantly increase back-pressure on the engine; must be monitored to avoid engine failure; modest fuel penalty	Can be used on almost any engine; complicated system with high installation costs	Not verified to be technically feasible for project source types
Catalyzed Diesel Particulate Filter (CDPF)	60 - 90%	$5,000-$7,000 for a 250 Hp engine	Annual filter cleaning ($200-300/year)	Significantly reduce CO, HC and PM emissions	Can significantly increase back-pressure on the engine; must be monitored to avoid engine failure	Exhaust temperature requirements make use with lightly loaded duty cycles not appropriate for use	Not verified to be technically feasible for project source types
Flow-Through Filter (FTF)	50 - 89%	$3,500-$5,000 for a 250 Hp engine	None	Significantly reduce CO, HC and PM emissions	Application limited to high duty cycles; slight fuel penalty	May require additional mounting hardware; space constraints on some equipment; requires a minimum exhaust temperature	Not verified to be technically feasible for project source types
Diesel Oxidation Catalyst (DOC)	20 - 75%	$300 - $1,500 for a 250 Hp engine	None	Significantly reduce CO, HC and reduce PM emissions	Few operational issues with proper design	Must fit within existing exhaust piping configuration and engine compartment	BACT
BACT Determination:	DOC is the only add-on control technology for CO & VOC that has been verified by the EPA and CARB that is technically feasible for the source types to be utilized for the project. It is expected DOC will provide similar HAP emissions reductions.						

SO_2

BACT Determination:	There are no available add-on controls for SO_2. BACT will be the use of ULSD fuel (<15 ppm sulfur content) for all diesel fired stationary sources associated with the project.

Table 1.—Emission Standards (g/kW-hr)

Rated Power (kW)	Tier	Model Year[1]	NOx	HC	NMHC + NOx	CO	PM
kW<8	Tier 1	2000	—	—	10.5	8.0	1.0
	Tier 2	2005	—	—	7.5	8.0	0.80
8≤kW<19	Tier 1	2000	—	—	9.5	6.6	0.80
	Tier 2	2005	—	—	7.5	6.6	0.80
19≤kW<37	Tier 1	1999	—	—	9.5	5.5	0.80
	Tier 2	2004	—	—	7.5	5.5	0.60
37≤kW<75	Tier 1	1998	9.2	—	—	—	—
	Tier 2	2004	—	—	7.5	5.0	0.40
	Tier 3	2008	—	—	4.7	5.0	
75≤kW<130	Tier 1	1997	9.2	—	—	—	—
	Tier 2	2003	—	—	6.6	5.0	0.30
	Tier 3	2007	—	—	4.0	5.0	
130≤kW<225	Tier 1	1996	9.2	1.3	—	11.4	0.54
	Tier 2	2003	—	—	6.6	3.5	0.20
	Tier 3	2006	—	—	4.0	3.5	
225≤kW<450	Tier 1	1996	9.2	1.3	—	11.4	0.54
	Tier 2	2001	—	—	6.4	3.5	0.20
	Tier 3	2006	—	—	4.0	3.5	
450≤kW≤560	Tier 1	1996	9.2	1.3	—	11.4	0.54
	Tier 2	2002	—	—	6.4	3.5	0.20
	Tier 3	2006	—	—	4.0	3.5	
kW>560	Tier 1	2000	9.2	1.3	—	11.4	0.54
	Tier 2	2006	—	—	6.4	3.5	0.20

[1] The model years listed indicate the model years for which the specified tier of standards take effect.

Table 1-1 (Revised February 2009)
Cape Wind Energy Project
Project Emissions Subject to OCS Permitting

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	15.9	0.8	0.0	5.1	0.8	0.6	937	0.0
Inside 25 Miles - Transit	15.7	0.7	0.0	4.9	0.8	0.6	896	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	369.8	13.9	3.6	41.4	24.7	23.1	20,411	0.2
Inside 25 Miles - Transit	355.2	12.3	3.6	32.8	24.2	22.6	18,679	0.2
Inside 25 Miles - Stationary Sources	14.6	1.6	0.0	8.6	0.5	0.5	1,732	0.0
Potential Emissions - Total	385.7	14.7	3.6	46.5	25.5	23.7	21,348	0.2
Inside 25 Miles - Transit	370.9	13.0	3.6	37.7	25.0	23.2	19,575	0.2
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 + 50% Construction)	200.8	7.8	1.8	25.8	13.2	12.2	11,143	0.1
Phase 1 - Year 2 (50% Construction)	184.9	7.0	1.8	20.7	12.4	11.6	10,206	0.1
Emissions Offsets	Total Emissions (Tons)							
	NO_X	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPS
Required Emissions Offsets (1.26:1 Offset Ratio)	486.0	0.0	0.0	0.0	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	27.0	1.3	0.0	10.9	1.4	1.1	1,475	0.0
Inside 25 Miles - Transit	27.0	1.3	0.0	10.9	1.4	1.1	1,475	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	2.4	0.0	20.1	2.6	2.0	2,726	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}, and $PM_{2.5}$ emissions from all vessels equipped with diesel engines subject to OCS permitting have been estimated using the appropriate emission factors from EPA's "Current Methodologies and Best Practices in Preparing Port Emission Inventories", January 2006. The CO_2 and 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.

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", January 2006

Diesel Fuel Sulfur Content:	500 ppm

Emission Factors for Ocean Going Vessel Main Engines using Residual Oil, g/kWh (Table 2-8)

Engine	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
OGV (Cat. 3)	14.0	0.50	0.21	1.10	1.14	1.10	705.33	0.00635

Emission Factors for Harbor Craft, g/kWh (Tables 2-15 & 2-16)

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	0.021	1.50	0.30	0.29	699.25	0.0161
450 - 559 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	699.25	0.0161
560 - 999 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	705.33	0.00635
1,000 kW (Cat. 1)	13.0	0.27	0.021	2.50	0.30	0.29	705.33	0.00635
1,000 - 3,000 kW (Cat. 2)	13.2	0.50	0.021	1.10	0.72	0.58	705.33	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)
CO_2 & HAP emission factors are from AP-42 (Sections 3.3 & 3.4)

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
6.86	1.14	0.01	3.02	1.00	1.00	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 carburated, 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	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	0.5	0.0	0.0	0.1	0.0	0.0	38.2	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	1.8	0.0	0.0	0.3	0.1	0.1	127.4	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	0.6	0.0	0.0	0.1	0.0	0.0	44.6	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	11.7	0.4	0.0	1.0	0.6	0.5	625.6	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	0.7	0.0	0.0	0.1	0.0	0.0	46.3	0.0
Multibeam Survey	26' Boat	1	300	224	Shallow area multibeam survey	8 days	10 hr/day	80		0.2	0.0	0.0	0.0	0.0	0.0	13.8	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										15.7	0.7	0.0	4.9	0.8	0.6	896	0.0
Total Preconstruction Emissions										15.9	0.8	0.0	5.1	0.8	0.6	937	0.0

All operating hours will be metered to track actual emissions.

Revised Feb. 2009

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", January 2006

Engine	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
	Emission Factors for Ocean Going Vessel Main Engines using Residual Oil, g/kWh (Table 2-8)							
OGV (Cat. 3)	14.0	0.50	0.21	1.10	1.14	1.10	705.33	0.00635

Engine Power	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
	Emission Factors for Harbor Craft, g/kWh (Tables 2-15 & 2-16)							
225 - 449 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	699.25	0.0161
450 - 559 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	699.25	0.0161
560 - 999 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	705.33	0.00635
1,000 kW (Cat. 1)	13.0	0.27	0.021	2.50	0.30	0.29	705.33	0.00635
1,000 - 3,000 kW (Cat. 2	13.2	0.50	0.021	1.10	0.72	0.58	705.33	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)
CO_2 & HAP emission factors are from AP-42 (Sections 3.3 & 3.4)

Diesel Fuel Sulfur Content:	500 ppm

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	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	0.5	0.0	0.0	0.0	0.0	0.0	27.8	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	23.7	0.8	0.3	1.9	1.9	1.9	1195.6	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		16.9	0.6	0.0	1.4	0.9	0.7	903.6	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			3.2	0.1	0.0	0.5	0.1	0.1	225.9	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		16.9	0.6	0.0	1.4	0.9	0.7	903.6	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	0.5	0.0	0.0	0.0	0.0	0.0	27.8	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	76.2	2.7	1.1	6.0	6.2	6.0	3837.0	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	102.1	3.6	1.5	8.0	8.3	8.0	5143.8	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			33.8	1.3	0.1	2.8	1.8	1.5	1807.3	0.0
Subtotal											273.9	9.9	3.1	22.1	20.3	19.0	14,072	0.1

Revised Feb. 2009

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", January 2006

	Emission Factors for Ocean Going Vessel Main Engines using Residual Oil, g/kWh (Table 2-8)							
Engine	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
OGV (Cat. 3)	14.0	0.50	0.21	1.10	1.14	1.10	705.33	0.00635
	Emission Factors for Harbor Craft, g/kWh (Tables 2-15 & 2-16)							
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	0.021	1.50	0.30	0.29	699.25	0.0161
450 - 559 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	699.25	0.0161
560 - 999 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	705.33	0.00635
1,000 kW (Cat. 1)	13.0	0.27	0.021	2.50	0.30	0.29	705.33	0.00635
1,000 - 3,000 kW (Cat. 2	13.2	0.50	0.021	1.10	0.72	0.58	705.33	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)
CO_2 & HAP emission factors are from AP-42 (Sections 3.3 & 3.4)

Diesel Fuel Sulfur Content:	500 ppm

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	Emissions (tons) NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
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	0.3	0.0	0.0	0.0	0.0	0.0	13.9	0.0
Put cable in place	crane barge	1	400	298		15 days	10 hrs/day	150	10 hrs/day for 15 work days		0.5	0.0	0.0	0.1	0.0	0.0	34.5	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		2.4	0.0	0.0	0.5	0.1	0.1	130.3	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		6.5	0.2	0.0	0.5	0.4	0.3	347.6	0.0
Moving crew in and out	crew boats	1	750	559		15 days	2 hrs/day	30			0.2	0.0	0.0	0.0	0.0	0.0	12.9	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	1.7	0.0	0.0	0.3	0.0	0.0	90.4	0.0
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		4.3	0.1	0.0	0.6	0.1	0.1	298.6	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		20.8	0.4	0.0	4.0	0.5	0.5	1129.5	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	0.2	0.0	0.0	0.0	0.0	0.0	10.4	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		0.1	0.0	0.0	0.0	0.0	0.0	4.6	0.0
Moving crew in and out	crew boat	1	750	559		10 days	2 hrs/day	20	1hr each way per crew boat		0.1	0.0	0.0	0.0	0.0	0.0	8.6	0.0
Subtotal											37.0	0.9	0.1	6.2	1.1	1.0	2,081	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	23.7	0.8	0.3	1.9	1.9	1.9	1195.6	0.0
Moving crew in and out	crew boats	4	750	559		130 days	2 hrs/day	260	2 days per WTG		6.4	0.2	0.0	1.0	0.2	0.2	447.9	0.0
Subtotal											30.1	1.0	0.4	2.8	2.1	2.1	1,644	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	0.8	0.0	0.0	0.1	0.0	0.0	41.7	0.0
Handling crane barge	attendant tug	1	3,000	2,237		1	16 hrs.	20	4 hrs. transit and 16 hrs. on site		0.7	0.0	0.0	0.1	0.0	0.0	34.8	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	0.6	0.0	0.0	0.0	0.0	0.0	31.3	0.0
Handling barge	attendant tug	1	3,000	2,237		6	3 hrs.	18			0.6	0.0	0.0	0.0	0.0	0.0	31.3	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	1.2	0.0	0.0	0.1	0.1	0.1	62.6	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	0.8	0.0	0.0	0.1	0.0	0.0	41.7	0.0
Setting the deck for ESP installation	crane barge	1	6,000	4,474		1	16 hrs.	16			1.1	0.0	0.0	0.1	0.1	0.1	55.6	0.0
Handling crane barge	attendant tug	1	3,000	2,237		2 trips	9 hrs/trip	18	12 hrs. out, 6 hours back		0.6	0.0	0.0	0.0	0.0	0.0	31.3	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		7.9	0.2	0.0	1.2	0.2	0.2	551.3	0.0
Subtotal											14.2	0.4	0.1	1.7	0.6	0.6	881	0.0
TOTAL Construction Emissions Over 1 to 2-Year Construction Duration											355.2	12.3	3.6	32.8	24.2	22.6	18,679	0.2

All operating hours will be metered to track actual emissions.

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

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

Diesel Fuel Sulfur Content:	15 ppm

Engine Size	NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
	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
	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
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		

* 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 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	Travel Origin beyond 25 Mile Radius	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 Feb. 2009

Cape Wind Energy Project
Operation Emissions Inside of 25 miles

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

Emission Factors from EPA's "Current Methodologies and Best Practices in Preparing Port Emission Inventories", January 2006

Engine	NOx	VOC (HC)	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
	Emission Factors for Ocean Going Vessel Main Engines using Residual Oil, g/kWh (Table 2-8)							
OGV (Cat. 3)	14.0	0.50	0.21	1.10	1.14	1.10	705.33	0.00635
	Emission Factors for Harbor Craft, g/kWh (Tables 2-15 & 2-16)							
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	0.021	1.50	0.30	0.29	699.25	0.0161
450 - 559 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	699.25	0.0161
560 - 999 kW (Cat. 1)	10.0	0.27	0.021	1.50	0.30	0.29	705.33	0.00635
1,000 kW (Cat. 1)	13.0	0.27	0.021	2.50	0.30	0.29	705.33	0.00635
1,000 - 3,000 kW (Cat.	13.2	0.50	0.021	1.10	0.72	0.58	705.33	0.00635

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)
CO_2 & HAP emission factors are from AP-42 (Sections 3.3 & 3.4)

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	Emissions (tons) NOx	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	CO_2	HAPs
Operation Period - Activities within 25 Miles of the Project																	
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	3.1	0.1	0.0	0.5	0.1	0.1	217.1	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	8.2	0.3	0.0	0.7	0.4	0.4	437.9	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	7.5	0.3	0.0	0.6	0.4	0.3	400.0	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	7.9	0.3	0.0	0.7	0.4	0.3	420.0	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										**27.0**	**1.3**	**0.0**	**10.9**	**1.4**	**1.1**	**1475.0**	**0.0**
Total Annual Operation Emissions (tons per year)										**27.0**	**1.3**	**0.0**	**10.9**	**1.4**	**1.1**	**1475.0**	**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.

Cape Wind OCS Permit Application: HAP Emission Factors - Diesel Engines

Diesel Engines<600 Hp: AP-42, Table 3.3-2			
Pollutant	**Emission Factor lb/MMBtu**	**Emission Factor g/hp-hr**	**Emission Factor g/kW-hr**
Benzene	9.33E-04	2.96E-03	3.97E-03
Toluene	4.09E-04	1.30E-03	1.74E-03
Xylenes	2.85E-04	9.05E-04	1.21E-03
1,3-Butadiene	3.91E-05	1.24E-04	1.66E-04
Formaldehyde	1.18E-03	3.75E-03	5.02E-03
Acetaldehyde	7.67E-04	2.44E-03	3.26E-03
Acrolein	9.25E-05	2.94E-04	3.94E-04
Naphthalene	8.48E-05	2.69E-04	3.61E-04
Total HAPS	**3.79E-03**	**1.20E-02**	**1.61E-02**

Diesel Engines>600 Hp: AP-42, Tables 3.4-3 & 3.4-4			
Pollutant	**Emission Factor lb/MMBtu**	**Emission Factor g/hp-hr**	**Emission Factor g/kW-hr**
Benzene	7.76E-04	2.46E-03	3.30E-03
Toluene	2.81E-04	8.92E-04	1.20E-03
Xylenes	1.93E-04	6.13E-04	8.21E-04
Formaldehyde	7.89E-05	2.51E-04	3.36E-04
Acetaldehyde	2.52E-05	8.00E-05	1.07E-04
Acrolein	7.88E-06	2.50E-05	3.35E-05
Naphthalene	1.30E-04	4.13E-04	5.53E-04
Total HAPS	**1.49E-03**	**4.74E-03**	**6.35E-03**

lb/MMBtu emission factors are from the referenced tables in AP-42
g/hp-hr = (lb/MMBtu)(453.6 g/lb)(MMBtu/10^6 Btu)(7000 Btu/hp-hr)
g/kW-hr = (g/hp-hr)(hp/0.746 kW)