OCS Study
BOEM 2017-079

BOEM Offshore Wind Energy Facilities Emission Estimating Tool

Technical Documentation

U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs
www.boem.gov

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Technical Documentation

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Published by

U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs
August 1, 2017

DISCLAIMER

Study concept, oversight, and funding were provided by the US Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Sterling, VA, under Contract Number M16PC00011. This report has been technically reviewed by BOEM and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the US Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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CITATION

Chang, R., B. Do, and R. Billings. 2017. Technical Documentation for the Offshore Wind Energy Facilities Emission Estimating Tool. US Dept. of the Interior, Bureau of Ocean Energy Management, Sterling, VA. OCS Study BOEM 2017-079. 51 pp.

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1.0 INTRODUCTION

The Bureau of Ocean Energy Management (BOEM) prepares numerous Environmental Assessments for construction operation plans as part of their National Environmental Policy Act (NEPA) responsibilities for proposed site characterization/geologic and geophysical activities and lease sales. To follow the Council on Environmental Quality regulations, BOEM needed to develop an efficient, consistent approach to estimate emissions associated with proposed actions. For offshore wind energy facilities, this approach could by extension include the potential beneficial impacts on climate change, by quantifying indirect impacts and reduction in emissions due to the displacement of grid-based, fossil fuel-generated electricity.

This Offshore Wind Energy Facilities Emission Estimating Tool for BOEM's NEPA document authors (and possibly project applicants) was developed to easily quantify emissions associated with proposed actions, and assess the associated benefits of offshore wind energy facilities.

In developing the Offshore Wind Energy Facilities Emission Estimating Tool, data were compiled that are needed to estimate offshore emissions associated with preconstruction, construction, operation and maintenance, and decommissioning of offshore wind power facilities. Backup generators used by wind turbines and offshore substations were included. Data were also compiled to estimate avoided fossil fuel combustion associated with switching to offshore wind power.

This technical document describes the tool itself, including general information on data inputs required for the tool and the tool's ultimate output. It also outlines the steps undertaken to compile the data required. The document discusses emissions associated with preconstruction, construction, operation and maintenance, and decommissioning of offshore wind power facilities, and avoided fossil fuel combustion emissions in two separate sections. This is not, however, a comprehensive user's guide. A separate user's guide is available to assist users in utilizing the tool.

Included in this technical document is an appendix that describes how to update data files in the future to account for changes in emission factors, vessel types and characteristics, changes to shore side electric generating power units, and greenhouse gas global warming potential factors.

2.0 OFFSHORE SOURCES

To develop the Offshore Wind Energy Facilities Emission Estimating Tool, data were compiled in order to estimate offshore emissions associated with each phase of offshore wind power facilities: preconstruction, construction, operation and maintenance, and decommissioning. A variety of vessel types were included to allow the user to develop a fleet profile for any region of the U.S. including the arctic.

There are two sources of emissions associated with these facilities: marine engines (used on vessels and as backup power supplies for turbines and substations) and helicopters. This section describes these two emissions sources and discusses the required input fields, the emission factors used in the tool, and the model defaults developed to estimate the emissions.

2.1 MARINE VESSEL/ENGINES

In all phases of the wind power operation, marine vessels are required to ferry supplies and crew to and from the offshore sites. The tool allows users to enter information about the fleet of vessels, as well as their anticipated activities. Information was compiled for a "typical" wind power installation to identify the expected marine vessel types that would be needed to support the offshore facilities throughout their useful life. Emergency generators used on offshore substations and wind turbines were also considered in this software tool. Section 3.1 presents the various vessel model defaults by vessel type.

To calculate emissions from marine vessels, the model requires the following data per phase:

- Vessel count,
- Propulsion hours per vessel, and
- Auxiliary hours per vessel.

The model calculates propulsion and auxiliary kilowatt hours (kW-hrs) of operation using the distance, speed, and total number of trips, as well as engine kW ratings and load factors. Users must provide an estimate of round trips by vessel type in order to generate the required activity (hours of operations). Users can use the model default vessel and engine characteristics or they can add their own vessel specific data if known. Vessel emissions are calculated for propulsion and auxiliary engines using the following basic equations:

Main Emissions (tons) = Vessel Count x main engine kW x main engine hours x load factor x emission factor (grams per kW-hour (g/kW-hr) x 1.10231E-6 (g to ton)

Auxiliary Emissions (tons) = Vessel Count x auxiliary kW x auxiliary hrs x load factor x emission factor (g/kW-hr) x 1.10231E-6 (g to ton)

Emergency generators used on offshore substations and wind turbines were assumed to be Category 1 engines with a power rating of 150 kW. Activity data required for these engines are annual hours of operation. Section 4 provides additional details about the equations the model uses for calculating emissions.

Information Handling Service (IHS) vessel population data were used to create weighted emission factors, taking into account the typical vessels' country of registration, engine categories, and regulatory tiers. These vessel profiles were combined with the tier level emission factors shown in Table 1 and the lead speciation profile shown in Table 2 to create weighted emission factors that account for variance in the vessel fleet. The weighted emission factors are presented in Table 3. These emission factors are disaggregated by main engine and auxiliary engines. ERG assumed that the auxiliary engines would be uncontrolled (Tier 0) Category 2 engines.

Table 1. Marine Vessel Emission Factors[1]

Domestic			Emission Factors (g/kW-hr)									
Engine Category	**Tier**	**Fuel Rate (g/Kw-hr)**	**CO_2**	**CH_4**	**N_2O**	**Black Carbon[2]**	**CO**	**NO_X**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**VOC**
1 and 2	0	203	648.2	0.004	0.031	0.2387	2.48	13.36	0.006	0.32	0.31	0.14
	1	203	648.2	0.004	0.031	0.2387	2.48	10.55	0.006	0.32	0.31	0.14
	2	203	648.2	0.004	0.031	0.2387	2	8.33	0.006	0.32	0.31	0.14
	3	203	648.2	0.004	0.031	0.0847	2	5.97	0.006	0.11	0.11	0.07
3	0	185	588.9	0.004	0.031	0.3234	1.4	14.7	0.362	0.45	0.42	0.63
	1	185	588.9	0.004	0.031	0.3234	1.4	14.7	0.362	0.45	0.42	0.63
	2	185	588.9	0.004	0.031	0.3234	1.4	14.7	0.362	0.45	0.42	0.63
	3	185	588.9	0.004	0.031	0.3234	1.4	14.7	0.362	0.45	0.42	0.63

[1] Unless otherwise indicated, the emission factors were obtained from USEPA, 2014 Commercial Marine Vessel-2014 NEI (https://www.epa.gov/air-emissions-inventories/2014-nei-resources-state-local-tribal-agencies).

[2] CEC. 2015. North American Black Carbon Emission Estimation Guidelines (2015) (http://www3.cec.org/islandora/en/item/11629-north-american-black-carbon-emissions-recommended-methods-estimating-black-en.pdf).

Table 2. Marine Speciation Profile for Lead

Engine Category	Pollutant	Associated Basis for Speciation	Speciation Profile (Unitless)
1 and 2	Lead	PM10	0.00015
3	Lead	PM10	0.0000262

Table 3. Weighted Marine Vessel Emission Factors[1]

Foreign			Emission Factors (g/kW-hr)									
Engine Category	**Tier**	**Fuel Rate (g/kW-hr)**	**CO_2**	**CH_4**	**N_2O**	**Black Carbon[2]**	**CO**	**NO_X[3]**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**VOC**
1 and 2	0	203	648.2	0.004	0.031	0.2387	2.48	9.8-17	0.006	0.32	0.31	0.14
	1	203	648.2	0.004	0.031	0.2387	2.48	9.8-17	0.006	0.32	0.31	0.14
	2	203	648.2	0.004	0.031	0.2387	2.48	7.7-14.4	0.006	0.32	0.31	0.14
	3	203	648.2	0.004	0.031	0.2387	2.48	1.96-3.4	0.006	0.11	0.31	0.14
3	0	185	588.9	0.004	0.031	0.3234	1.4	9.8-17	0.362	0.45	0.42	0.63
	1[4]	185	588.9	0.004	0.031	0.3234	1.4	9.8-17	0.362	0.45	0.42	0.63
	2[4]	185	588.9	0.004	0.031	0.3234	1.4	7.7-14.4	0.362	0.45	0.42	0.63
	3[4]	185	588.9	0.004	0.031	0.3234	1.4	1.96-3.4	0.362	0.45	0.42	0.63

[1] Unless otherwise indicated, the emission factors were obtained from USEPA, 2014 Commercial Marine Vessel-2014 NEI (https://www.epa.gov/air-emissions-inventories/2014-nei-resources-state-local-tribal-agencies).

[2] CEC. 2015. North American Black Carbon Emission Estimation Guidelines (2015). (http://www3.cec.org/islandora/en/item/11629-north-american-black-carbon-emissions-recommended-methods-estimating-black-en.pdf).

[3] Varies by engine speed.

2.2 HELICOPTER

For support helicopters, four typical helicopter types were considered (i.e., single engine, twin light, twin medium, and twin heavy). A typical speed was assigned to each helicopter type, which users can adjust to more accurately represent the helicopters they plan to use. The user must provide distance from the centroid of the offshore windfarm (which is the latitude and longitude coordinates that mark the geographic center of the project) to the closest support airport as well as the number of round trips anticipated for each phase of the project.

The helicopter speed and distance to the local airport are used to calculate transit time for each round trip; transit time is multiplied by the number of trips to get total support helicopter hours by helicopter type. These activity data are applied to the compiled helicopter emission factors from the Swiss Federal Office of Civil Aviation summarized in Table 4 below.

Table 4. Support Helicopter Emission Factors[1]

Helicopter Type	Fuel Usage (gal/hr)	Emission Factors (lbs/hr)								
		CO_2	CH_4	N_2O	Black Carbon[2]	CO	NO_X	SO_2	PM	VOC
Single	45.36	956.92	0.03	0.03	0.009	0.07	2.32	0.3	0.07	1.89
Twin Light	75.35	1,589.69	0.04	0.05	0.012	0.10	3.14	0.5	0.09	4.28
Twin Medium	116.59	2,459.92	0.07	0.08	0.026	0.20	7.22	0.78	0.20	3.48
Twin Heavy	314.74	6,640.46	0.19	0.22	0.105	0.82	34.66	2.11	0.80	2.67

[1] Unless otherwise indicated, all emission factors were obtained from: Swiss Federal Office of Civil Aviation, 2015; Guidance on the Determination of Helicopter Emissions (https://www.bazl.admin.ch/bazl/en/home/specialists/regulations-and-guidelines/environment/pollutant-emissions/triebwerkemissionen/guidance-on-the-determination-of-helicopter-emissions.html).

[2] CEC. 2015. North American Black Carbon Emission Estimation Guidelines (2015) (http://www3.cec.org/islandora/en/item/11629-north-american-black-carbon-emissions-recommended-methods-estimating-black-en.pdf).

3.0 AVOIDED EMISSIONS

To quantify emissions associated with conventional power generation that offshore wind farms will replace, the user is required to provide an estimate of the quantity of energy that the offshore wind farm is designed to generate. The anticipated wind farm power generation is typically quantified in the design phase of the project, accounting for the power rating of the wind turbines and local wind conditions.

Estimating the amount of energy that is avoided by using electricity generated from the offshore wind farm also requires knowledge of the regional mix of energy sources used to generate grid-connected electric energy in the portion of the U.S. electric grid served by the planned offshore wind farm. The USEPA's Emissions & Generation Resource Integrated Database (eGRID) is a comprehensive database detailing emissions from electricity generating units in the United States accounting for regional mix of energy sources.

The USEPA's eGRID provides emission factors for major greenhouse gases (GHGs)--CO_2, CH_4, and N_2O; NO_x, and SO_2; in grams emitted per megawatt (g/MW). Argonne National Laboratory (ANL) provides the emission factors for CO, PM_{10}, $PM_{2.5}$, and VOC for the corresponding North American Electrical Reliability Corporation (NERC) regions. The emission factors from both eGRID and ANL are associated with emissions at the point of electricity generation. The geographic resolution and source of emissions data, however, vary between the eGRID and ANL emission factors. Table 5 summarizes the key characteristics of the emission factors utilized in the model.

Table 5. Key Characteristics of Emission Factors Utilized for Avoided Emissions

<table>
<tr><th>Pollutant</th><th>Source</th><th>Boundaries</th><th>Geographic Resolution</th><th>Source of Emissions Data</th></tr>
<tr><td>CO_2</td><td rowspan="5">eGRID</td><td rowspan="11">Captures emissions at point of electricity generation</td><td rowspan="5">eGRID subregions</td><td rowspan="5">Plant-specific data for all U.S. electricity generating plants that provide power to the electric grid and report data to the U.S. Government</td></tr>
<tr><td>CH_4</td></tr>
<tr><td>N_2O</td></tr>
<tr><td>NO_x</td></tr>
<tr><td>SO_2</td></tr>
<tr><td>CO</td><td rowspan="6">ANL</td><td rowspan="6">NERC regions</td><td rowspan="5">National average fuel combustion emissions data</td></tr>
<tr><td>PM_{10}</td></tr>
<tr><td>$PM_{2.5}$</td></tr>
<tr><td>VOC</td></tr>
<tr><td>Pb</td></tr>
<tr><td>Black Carbon[a]</td><td>Average U.S. technology life-cycle emission factors applied to the eGRID subregion technology mix (adjusted to remove emissions upstream from point of electricity generation)</td></tr>
</table>

The eGRID/ANL emission factors are applied to the user supplied estimates of energy generation associated with the offshore wind farm to estimate emissions avoided, using the following equation:

$$EO_i = GP/1{,}000{,}000 \times EF_{ij}/2{,}000$$

Where:

EO_i = Annual emissions avoided for pollutant i (tons)
GP = Anticipated annual power generation (terawatt-hrs)
1,000,000 = Conversion from terawatt-hrs to megawatt-hrs
EF_{ij} = E=eGRID emission factor for pollutant i and region j (lbs/megawatt)
2,000 = Conversion factor lbs to tons.

Table 6 lists the emission factors used for the avoided emissions calculations. The eGRID/ANL emission factors are not full lifecycle emission factors and thus do not account for activities upstream of power generation such as fuel extraction and fuel delivery to electric generating units.

Table 6. Avoided Emission Factors by Coastal Region$^{g/MWh}$

Acronym	Sub-region Name	Associated NERC Region	CO_2	CH_4	N_2O	NO_x	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	BC	PB
AKMS	ASCC Miscellaneous	ASCC	1,708,208.91	80.05	13.82	23,380.42	9.00	2,455.30	253.00	11.66	2.50	1.34	0.01
CAMX	ASCC Alaska Grid	ASCC	477,006.35	21.74	3.56	1,237.40	9.00	325.68	253.00	216.01	191.53	1.76	0.00
CAMX	WECC California	WECC	414,533.08	16.11	1.89	109.32	16.00	25.40	186.00	216.01	191.53	1.76	0.00
ERCT	ERCOT All	TRE	630,234.39	38.81	5.41	296.20	17.00	861.37	170.00	62.87	47.73	1.85	0.04
FRCC	FRCC All	FRCC	548,377.75	37.26	5.10	281.68	10.00	384.19	179.00	45.82	75.59	1.57	0.02
HIMS	HICC Miscellaneous	HICC	602,907.72	64.82	10.24	5,213.59	24.00	2,304.25	267.00	84.21	81.29	3.30	0.03
HIOA	HICC Oahu	HICC	666,844.74	63.53	10.16	1,473.27	24.00	3,987.08	267.00	235.53	363.69	7.90	0.05
MROE	MRO East	MRO	820,392.11	91.14	13.35	570.17	22.00	1,466.01	210.00	164.83	125.88	3.57	0.05
MROW	MRO West	MRO	922,006.32	108.12	15.56	1,059.59	22.00	1,700.97	210.00	109.81	78.91	1.77	0.04
NEWE	NPCC New England	NPCC	483,535.36	48.95	6.67	193.68	25.00	253.10	406.00	394.12	330.70	2.85	0.01
NWPP	WECC Northwest	WECC	708,634.21	69.87	10.04	830.53	16.00	458.13	186.00	55.01	41.52	1.28	0.04
NYCW	NPCC NYC/Westchester	NPCC	595,456.56	11.74	1.35	251.29	25.00	49.90	406.00	1.93	1.88	1.20	0.00
NYLI	NPCC Long Island	NPCC	610,260.91	19.88	2.59	347.00	25.00	361.06	406.00	79.38	110.93	3.73	0.01
NYUP	NPCC Upstate NY	NPCC	541,884.12	41.03	5.63	357.43	25.00	753.42	406.00	77.13	62.23	0.93	0.01
RFCE	RFC East	RFC	667,970.10	54.31	7.86	527.98	16.00	1,275.05	145.00	33.89	25.52	1.20	0.02
RFCM	RFC Michigan	RFC	845,302.49	87.99	12.66	747.97	16.00	2,066.57	145.00	484.57	353.04	8.21	0.06
RFCW	RFC West	RFC	884,425.29	91.90	13.54	735.73	16.00	2,513.81	145.00	87.95	64.74	2.34	0.06
SRMV	SERC Mississippi Valley	SERC	567,134.70	38.80	5.48	538.41	14.00	659.52	149.00	50.93	37.77	1.96	0.03
SRSO	SERC South	SERC	693,047.41	61.92	9.10	486.70	14.00	1,833.42	149.00	106.26	77.89	2.15	0.04
SRVC	SERC Virginia/Carolina	SERC	647,495.85	64.30	9.21	358.34	14.00	577.88	149.00	105.77	80.60	1.11	0.03

4.0 GLOBAL WARMING POTENTIAL (GWP)

The model also calculates total GHG emission estimates in CO_2 equivalents (CO_2e). Because GHGs differ in their warming influence due to their different radiative properties and lifetimes in the atmosphere, the CO_2 equivalent was developed to express the warming influences in a common metric. The common metric is called the CO_2-equivalent emission, which is the amount of CO_2 emissions that would cause the same warming influence as an emitted amount of a long-lived GHG or a mixture of GHGs. The equivalent CO_2 emissions are obtained by multiplying the CH_4 and N_2O emissions by their global warming potential (GWP). For a mix of GHGs it is obtained by summing the equivalent CO_2 emissions of each gas. The GWP values are presented in Table 7.

Table 7. GWP Value

GHG	GWP Value
CH_4	25
N_2O	298

5.0 MODEL DEFAULTS

The model provides default values for marine vessels and helicopters if users do not have the vessel and helicopter data required to estimate emissions.

5.1 MARINE VESSEL DEFAULTS

Table 8 summarizes the defaults for marine vessels.

Table 8. Default Vessel Characteristics

Vessel Type	Default		
	Knots	Main kW	Aux kW
Anchor Handling Tugs	12	5,733	1,237
Barge	20	22,424	3,020
Cable Laying	12	6,658	3,026
Crew	22	3,013	201
Dredging	11	3,234	964
Ice Breaker	16	17,844	965
Jackup	7	3,215	895
Research/Survey	12	2,997	1,363
Shuttle Tanker	15	17,484	30,769
Supply Ship	12	3,843	874
Tug	12	2,053	238

The model also requires load factors for marine vessels. The load factor defaults are

- 0.82 for transit propulsion,
- 0.2 for maneuvering propulsion, and
- 1.00 for auxiliary power.

5.2 Helicopter Defaults

The model provides default helicopter speeds by helicopter type (Table 9). Alternatively, users can use specific speeds associated with the helicopters they intend to use in their offshore project.

Table 9. Default Helicopter Speeds by Helicopter Types

Helicopter Type	Speed (mph)
Single	157.5
Twin Light	177
Twin Medium	182.6
Twin Heavy	188.2

5.3 Avoided Emission Defaults

For the tool to calculate the avoided emissions, the user will need to enter the total rated power of the planned offshore energy facility in megawatts (MW), the forecasted capacity factor as a percentage (in aggregate), the zip code of the location at which the offshore wind energy facility will be connected to the shore-based grid, and an estimated transmission loss factor (as a percentage of the energy lost between the point of generation and the point of connection to the shore-based grid).

If transmission loss is not known, a default transmission loss factor of 3 percent can be used, assuming the use of high-voltage direct-current (HVDC) transmission technology.[1] The Offshore Wind Energy Facilities Emission Estimating Tool will enable users to enter a custom transmission loss factor if one specific to the planned offshore wind energy facility is known.

6.0 SOFTWARE CALCULATIONS

The Offshore Wind Energy Facilities Emission Estimating Tool calculates vessel emission vessel emissions as two separate activities: 1) transit operations to and from the site and 2) onsite working operations that covers the duration the vessel is on site supporting the construction maintenance or removal activity.

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[1] Siemens, 2015. "Siemens revolutionizes grid connection for offshore wind power plants." http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2015/energymanagement/pr2015100358emen.htm&content[]=EM

Vessel and helicopter transit emissions based on the distances to port provided by the user. The tool provides the emissions broken out by where they occur. That is separate totals are provided in the final export that note the emission that occur within 25 miles of the platform, and the emission associated with each port. Figure 1 provides a graphical illustration of the emissions divisions. In the figure, there are transit emission from State A and State B to the installation. Those transit emissions occurring within 25 miles of the installation centroid are combined as part of the installation total emissions. The transit emissions outside the 25-mile radius of the installation, are allocated to the port state. So, in Figure 1, the emissions that occur along the red portion of the line from State A to the installation would be in State A total emissions.

In the case of multiple states supporting an installation, where the 25-mile offshore boundary is further away than the 25-mile radius around the project, which could introduce a scenario in which a route affects 2 states and needs to be examined outside the tool. For example, in Figure 1 the transit line from State B to the installation passes through State A waters and waters further than 25-miles from the state. The tool allocates all the emissions along the blue portion of the line to State B. Technically, the emissions associated with the portion of the blue line within State A waters should be allocated to State A. Additionally, the emissions for the small portion of the line outside 25-miles of the state boundary but outside the 25-mile radius of the installation should go unallocated. Again, the more refined estimates of state emission for a route similar to the State B route would need to be examined outside the tool with a geographic analysis.

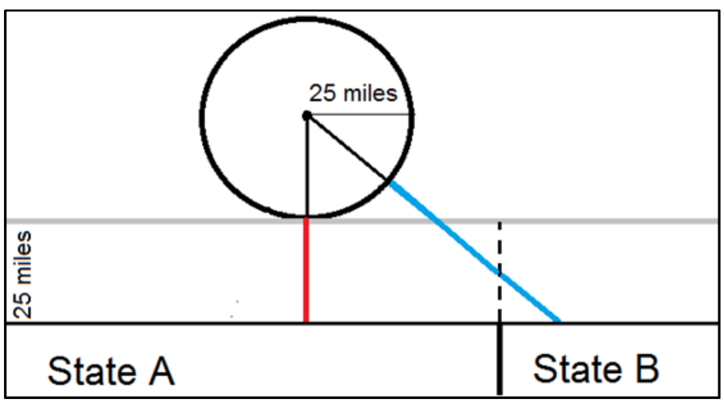


Figure 1. Diagram of example emission calculation scenarios

The following section outline the equations used in the software for distances within 25 miles of the installation, and distances greater than 25 miles from the platform.

6.1 TRANSIT EMISSIONS, DISTANCE WITHIN 25 MILES OF THE INSTALLATION

Six equations are built into the tool to calculate transit emissions where the distance to from the installation is less than or equal to 25 miles.

The number of hours the vessel is in transit is calculated as:

$$HR_{v,\leq 25} = \left(\frac{(D*VC*TR*2)}{SP}\right) \qquad \text{(Equation 1)}$$

Where:

$HR_{v,\leq 25}$ = Hours of operation for operations within 25 miles of installation centroid
D = Distance from installation centroid, ≤ 25 nautical miles
VC = Vessel count
TR = Trips
SP = Vessel speed (knots)

The vessel emissions due to propulsion engines during transit for pollutant X are calculated as:

$$V_{Pt,X} = 1.1023E^{-6} \times EF_{Px} \times HR_{v,\leq 25} \times PR \times LF_{Pt} \quad \text{(Equation 2)}$$

Where:

$V_{Pt,X}$ = Propulsion emissions of pollutant X (tons)
EF = Propulsion emission factor for pollutant X (g/kW-hr)
$HR_{v,\leq 25}$ = Hours of operation within 25 miles of installation centroid
PR = Main engine power rating (kW)
LF_{Pt} = Load factor for propulsion engines during transit (default is 0.82)

The vessel emissions due to auxiliary engines during transit for pollutant X are calculated as:

$$V_{A,X} = 1.1023E^{-6} \times EF_{Ax} \times HR_{v,\leq 25} \times APR \times LF_{A} \quad \text{(Equation 3)}$$

Where:

$V_{A,X}$ = Auxiliary emissions of pollutant X (tons)
EF = Auxiliary emission factor for pollutant X (g/kW-hr)
$HR_{v,\leq 25}$ = Hours of operation within 25 miles of installation centroid
PR = Auxiliary engine power rating (kW)
LF_{A} = Load factor for auxiliary engines during transit (default is 1).

The total transit emissions are then calculated by summing the calculated propulsion engine and auxiliary emissions:

$$Q_{t,X} = V_{A,X} + V_{Pt,X} \quad \text{(Equation 4)}$$

Where:

$Q_{t,X}$ = Total Transit emissions tons
$V_{A,X}$ = Auxiliary transit emissions (tons)
$V_{Pt,X}$ = Propulsion transit emissions (tons)

For helicopters, emissions are estimated based on the number of hours in transit.

The number of hours the helicopter is in transit is calculated as:

$$HR_{H,\leq 25} = \left(\frac{(HC * HTR * D * 2)}{[HSP]}\right) \quad \text{(Equation 5)}$$

Where:

$HR_{H,<25}$ = Helicopter hours within 25 miles of installation centroid
HC = Helicopter count
HTR = Helicopter trips
D = distance from centroid of project to nearest heliport (miles)
HSP = Helicopter speed (miles per hour)

Helicopter emissions within 25 nautical miles of the installation are calculated as:

$$Q_H = \frac{EF_{Hx} \times HR_H}{2000\left(\frac{lb}{ton}\right)} \quad \text{(Equation 6)}$$

Where:

Q_H = Helicopter emissions (tons)
EF_{Hx} = Helicopter emission factor for pollutant X (pounds per hour)
HR_H = Number of hours helicopter is in transit.

6.2 Transit Emissions, Outside 25 Miles of Installation

Number of hours the vessel is in transit:

The number of hours the vessel is in transit is calculated as:

$$HR_{v,\leq 25} = \left(\frac{((D-25)*VC*TR*2)}{SP}\right) \quad \text{(Equation 7)}$$

Where:

$HR_{v,\leq 25}$ = Hours of operation for operations beyond 25 miles
D = Total distance from port to installation centroid (> 25 nautical miles)
VC = Vessel count
TR = Trips
SP = Vessel speed (knots)

Vessel emissions due to propulsion engines during transit >25 nautical miles for pollutant X is the same as Equation 2, and vessel emissions due to auxiliary engines during transit for pollutant X are the same as Equation 3.

Like vessels, the change to the helicopter equation occurs in the distance used in the hours calculation:

$$HR_{H,\leq 25} = \left(\frac{(HC*HTR*(D-25)*2)}{[HSP]}\right) \quad \text{(Equation 8)}$$

Where:

$HR_{h,<25}$ = Helicopter hours
HC = Helicopter count
HTR = Helicopter trips
D = Distance from installation centroid to specified heliport (miles)
HSP = Helicopter speed (miles per hour)

The calculation for helicopter emissions > 25 nautical miles remains the same as Equation 6.

6.3 Onsite Emissions

Onsite emissions are calculated separately within the tool. These emissions are combined with the transit emissions within 25 miles of the installation centroid (Section 6.1).

Hours on site are calculated as:

$$HR_o = (TD \times 24) - HR_{v,\leq 25} - HR_{v,>25} \qquad \text{(Equation 9)}$$

Where:

HR_o = Hours on site
TD = Total project days
$HR_{v,<25}$ = Hours within 25 miles of the project
$HR_{v,>25}$ = Hours beyond 25 miles of the project

Propulsion engine emissions:

$$V_{Po,X} = 1.1023E^{-6} \times EF_{Px} \times HR_o \times PR \times LF_{Po} \qquad \text{(Equation 10)}$$

Where:

$V_{Po,X}$ = Total propulsion emissions of pollutant x (tons)
EF_{px} = Propulsion emission factor for pollutant x (g/kW-hr)
HR_o = Hours on site
PR = Main engine power rating (kW)
LF_{Po} = Load factor for propulsion engines during on-site maneuvering (default is 0.2).

Vessel emissions due to auxiliary engines on site for pollutant X are calculated as:

$$V_{A,X} = 1.1023E^{-6} \times EF_{Ax} \times HR_o \times APR \times LF_A \qquad \text{(Equation 11)}$$

Where:
$V_{A,X}$ = Auxiliary emissions of pollutant X (tons)
EF = Auxiliary emission factor for pollutant X (g/kW-hr)
HR_o = Hours of operation on site
PR = Auxiliary engine power rating (kW)
LF_A = Load factor for auxiliary engines during transit (default is 1)

Total onsite emissions then are calculated as:

$$Q_{t,X} = V_{Ao,X} + V_{Po,X} \qquad \text{(Equation 12)}$$

Where:
$Q_{t,X}$ = Total on site emissions (tons)
$V_{Ao,X}$ = Auxiliary emissions on site for pollutant x.
$V_{Po,X}$ = Propulsion emissions on site for pollutant x.

Appendix A

BOEM Wind Energy Facility Emission Estimation Tool Maintenance Screen Guide

CONTENTS

LIST OF FIGURES

1.0 Introduction

The Offshore Wind Energy Facilities Emission Estimating Tool comes with a set of maintenance routines to allow BOEM to update emissions factors, default values, and other calculation parameters to increase the longevity of the software.

The maintenance tools are accessible from the "Maintenance" button on the Wind Energy Tool Main Screen (Figure 1). After clicking the "Maintenance" button, the user is prompted to enter a password for access to the maintenance options (Figure 2). The password is: **BOEMOnly**

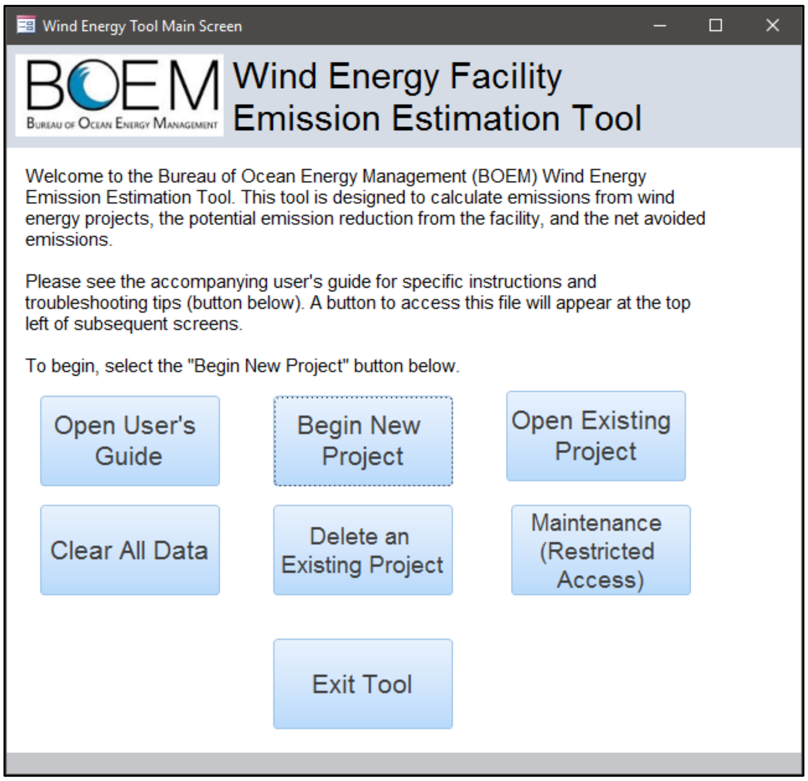


Figure 1. Wind energy tool main screen

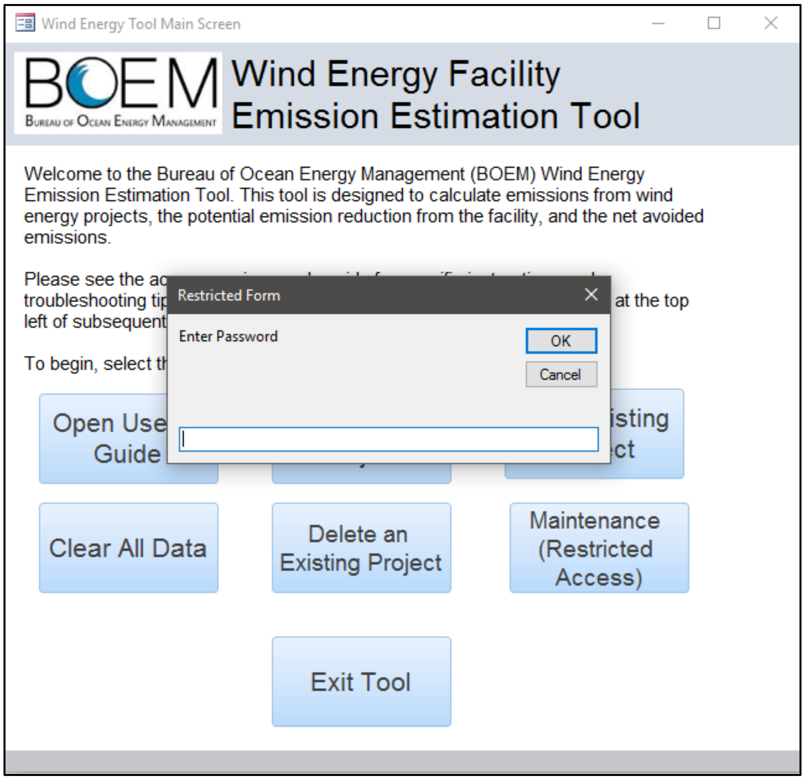


Figure 2. After clicking the maintenance button, the tool requests a password

After entering the password, the main maintenance screen (Figure 3) opens. The Maintenance screen consists of four tabs:

- Vessel Parameters: Options to update propulsion and auxiliary vessel information
- Equipment Parameters: Options to update helicopter, substation, and avoided emission information
- GWPs: options to update Global Warming Potentials (GWPs)
- Add Equipment: options to add new vessels, helicopters, substation/engine types, or ports

The following sections discuss each of the tabs in turn.

The main maintenance screen also has four buttons along the top:

- Export All Default Values: Allows the user to export all default values (i.e., emission factors and attributes) to a single excel file.
- Save as New Version of Tool: Saves the current database as a new version of the tool, in a location of the user's choosing. Clears all project data prior to saving. Discussed further in Section 6.
- Back to Tool Main Screen: Closes the Maintenance window and returns to the Wind Energy Tool Main Screen.
- Close Tool: Exits the tool.

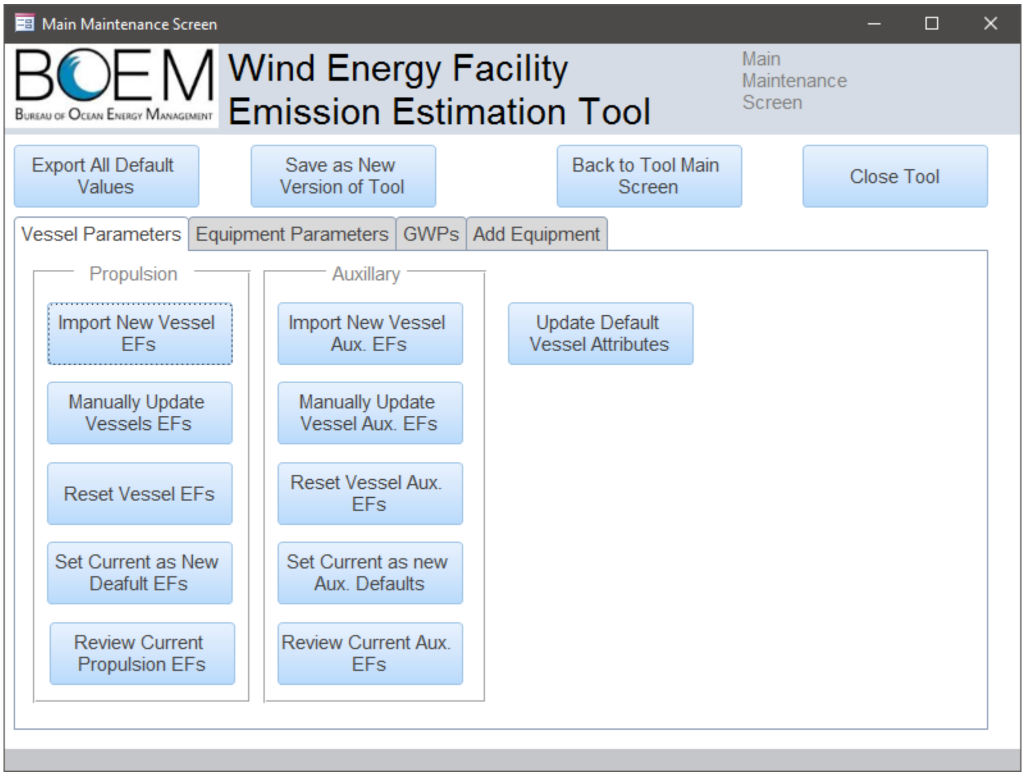


Figure 3. Wind energy tool main maintenance screen

2.0 Vessel Parameters Tab

The “Vessel Parameter” tab (Figure 4) contains several options to edit both propulsion and auxiliary engines. The majority of the options center around the emission factors (EFs). There are two sets of saved emission factors within the tool: defaults and current. Defaults are the initial set of factors the tool was built with. The “Current” factors, are those currently used in the equations. Initially, the current factors are the same as the default factors. The maintenance screens are designed to allow BOEM to change the “Current” factors to new factors for testing purposes (i.e., allow BOEM to see how emission estimates would change with a revised factor or set of factors), and then be able to easily revert their copy of the tool back to the default factors. The revised factor can become permanent by changing the defaults to match. BOEM can then save this copy with a new version number for distribution to operators.

There are several maintenance options for the current and default emission factors:

- Import New EFs: Imports new EFs from a file
- Manually Update EFs: manually changes the emission factors via form
- Reset EFs: resets the emission factors to the saved default values
- Set Current as New Default EF: replaces default EFs with the current emission factors
- Review Current EFs: Opens a window with the current EFs
- Update Default Vessel Attributes: Opens a new window to edit the default vessel attributes

Since the maintenance screens have been developed to be similar for the different engine types, this manual will only walk through the propulsion screens. Each of these options will be discussed in the following subsections.

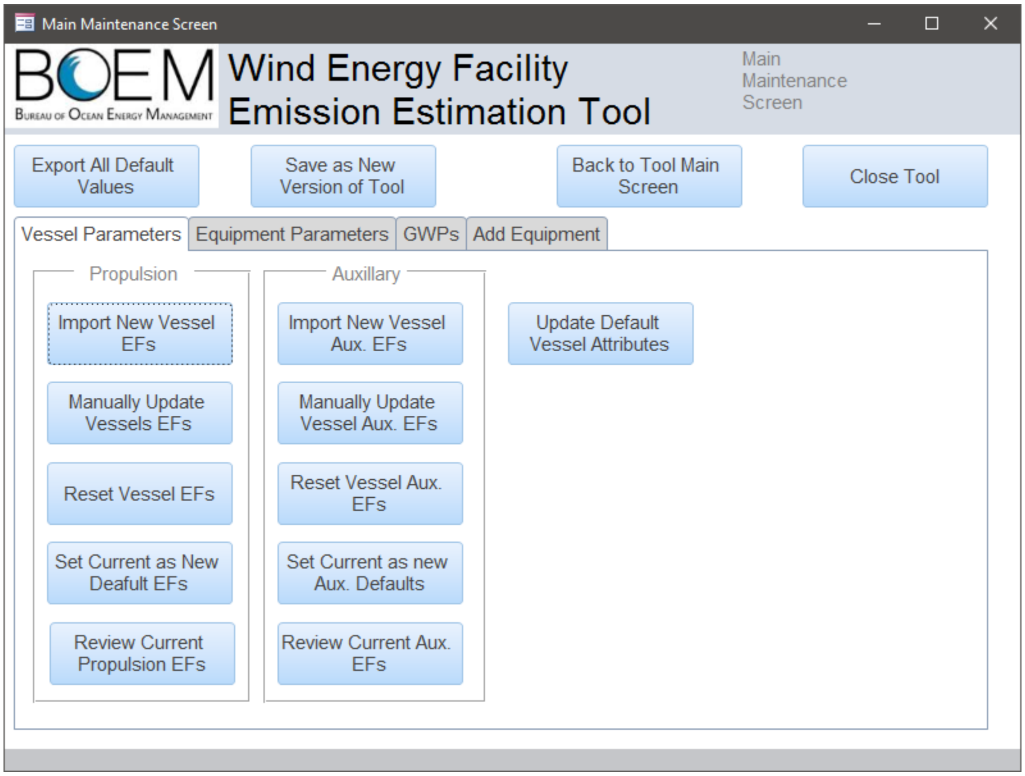


Figure 4. Wind energy tool main maintenance screen, vessel parameter tab

2.1 IMPORT NEW EFS

Since there are several vessel types and multiple pollutants, manually editing multiple vessel types could become cumbersome and prone to error. To streamline the process, an import feature was provided in the tool.

The import button opens a window to navigate to the file location. Templates for emission factor imports are provided in the templates folder provided with the tool (\WindEneryTool_V1.0 - BOEMCopy\Maintenance_Templates\).

Once the file is selected, the file is automatically imported to the Current EF table and is available for calculations. A pop-up window recommends reviewing the imported factors using the appropriate “Review Current EF” button (Section 2.5), to ensure values were imported properly.

If BOEM wants to make these values the new defaults, they will need to click the appropriate “Set Current as New Defaults” button. Further instructions are in Section 2.4.

2.2 MANUALLY UPDATE EFS

The second option on the maintenance screen is to manually change the current emission factors. This option is best for edits to only one or two factors. For multiple factors, importing the factors (Section 2.1) is the better option.

Clicking the “Manually Update EFs” button opens a separate window (Figure 5) where the user can select the vessel type (Figure 6) and pollutant (Figure 7) to be edited from the drop downs at the top. This will populate the form with the emission factor data. The user can update the emission factor in the box at the bottom of the screen (Figure 8).

After making the edits, the user should click the “Save New Factor” button. This will save the edit in a staging table and clear the form to allow for additional edits. Once all edits are completed, the user should click the “Review and Accept Changes” button. This will open a separate window (Figure 9) with a summary of the saved changes, and various options to save and continue via the buttons at the top of the screen. Options include:

- Close form, without making changes: Closes the review form without making changes, and returns to the “Manually Edit Defaults” screen to make more edits.
- Make changes; return to make additional edits: Saves the current list of changes, clears the list, and returns the user to the “Manually Edit Defaults” screen to make more edits.
- Make changes; return to Maintenance: Saves the current list of changes, clears the list, and returns the user to the main “Maintenance” screen.
- Make changes; return to make additional edits: Saves the current list of changes, clears the list, and returns the user to the “Main” screen of the tool.

Other options on the Manually Edit EFs screen (Figure 5) include:

- Clear Form: Clears current data on screen without saving. No changes are saved.
- Clear All and return to Maintenance Screen: Clears staging table and returns to the main Maintenance screen. No changes are saved.

If BOEM wants to make these values the new defaults, they would need to click the appropriate “Set Current as New Defaults” button. Further instructions are in Section 2.4.

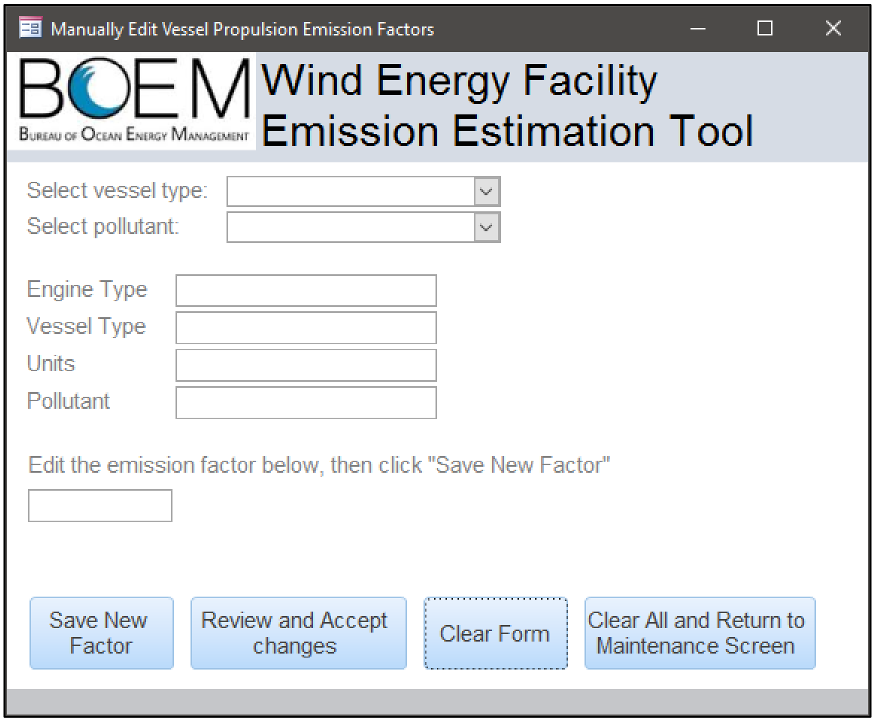


Figure 5. Manually edit vessel EF screen

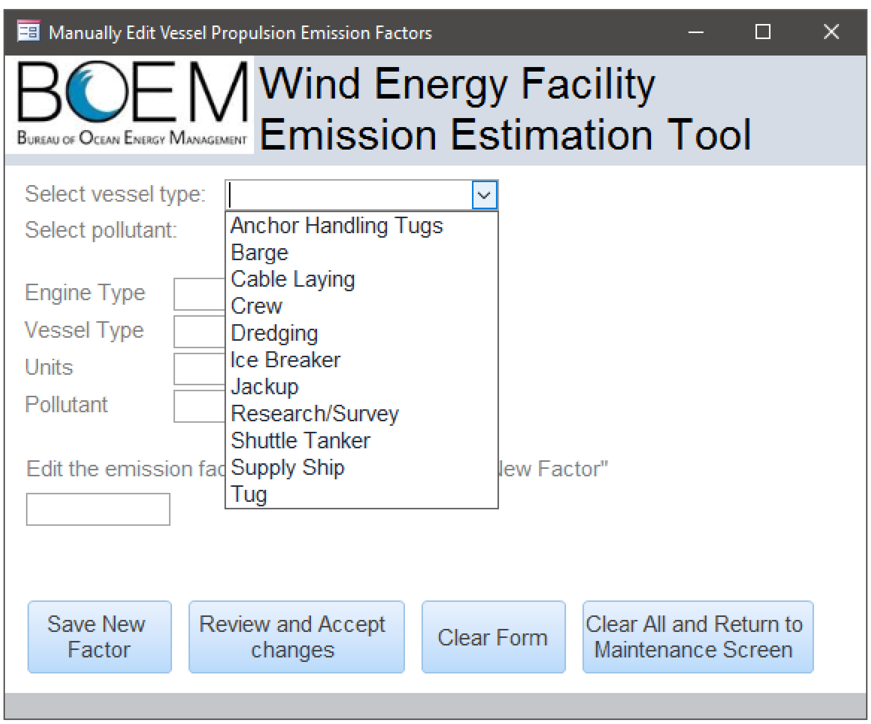


Figure 6. Vessel selection options for manual edit screen

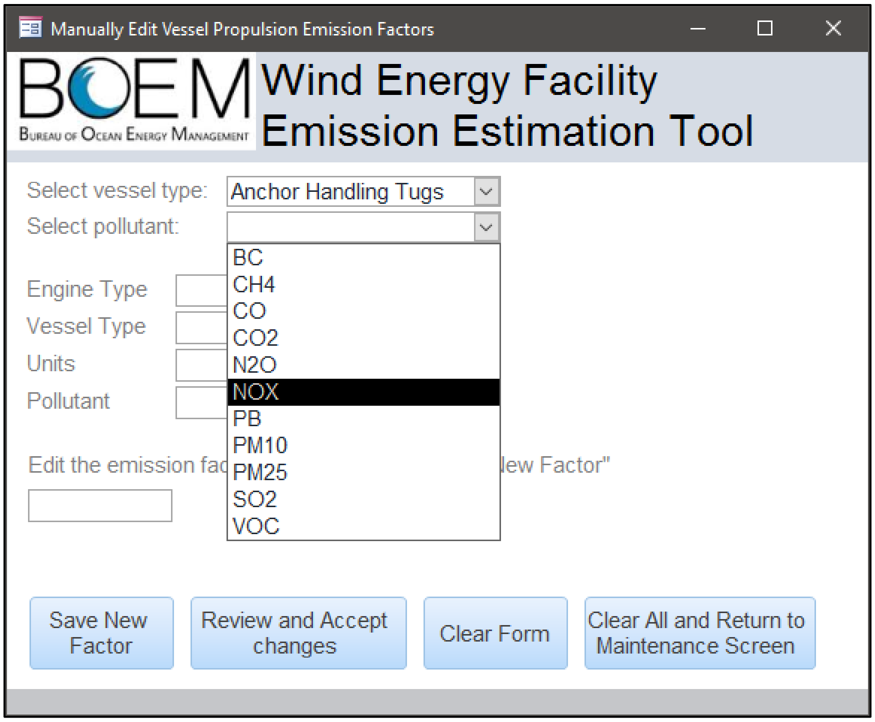


Figure 7. Pollutant selection options

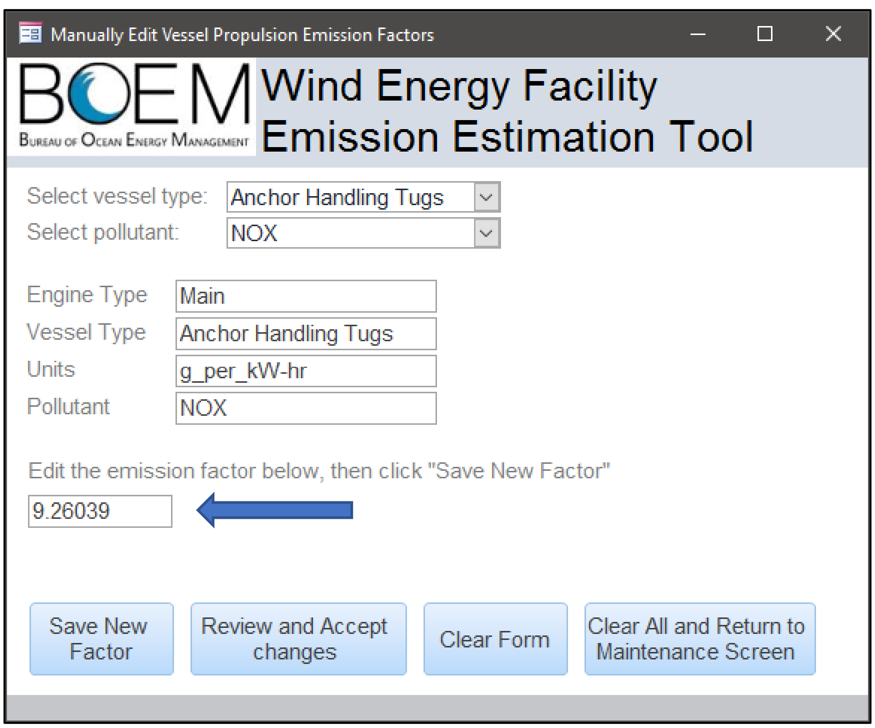


Figure 8. Edits can be made to the emission factor in the box at the bottom of the form (highlighted by the blue arrow)

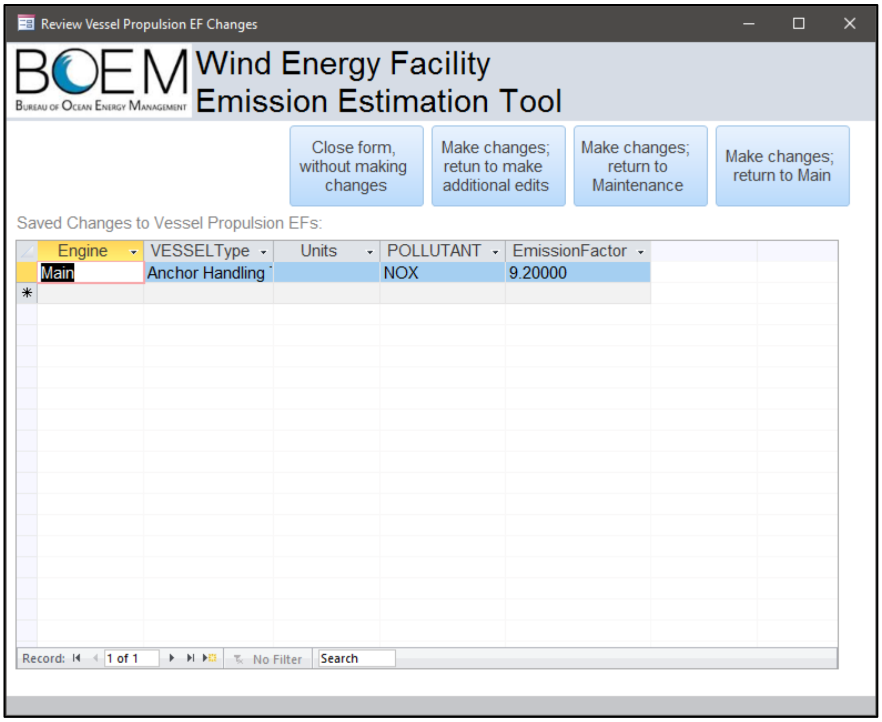


Figure 9. Review and accept changes screen

2.3 Reset EFs

The Maintenance screen provides the option to revert the current emission factors back to the saved defaults. This allows the return of the personal copy of the tool back to the initial state after testing the implications of a change to the emission factor.

Clicking the "Reset EFs" button automatically initiates the code to reset the current EFs to the default values. A pop-up window (Figure 10) opens when the process is complete, and recommends reviewing the current factors using the appropriate "Review Current EF" button (Section 2.5).

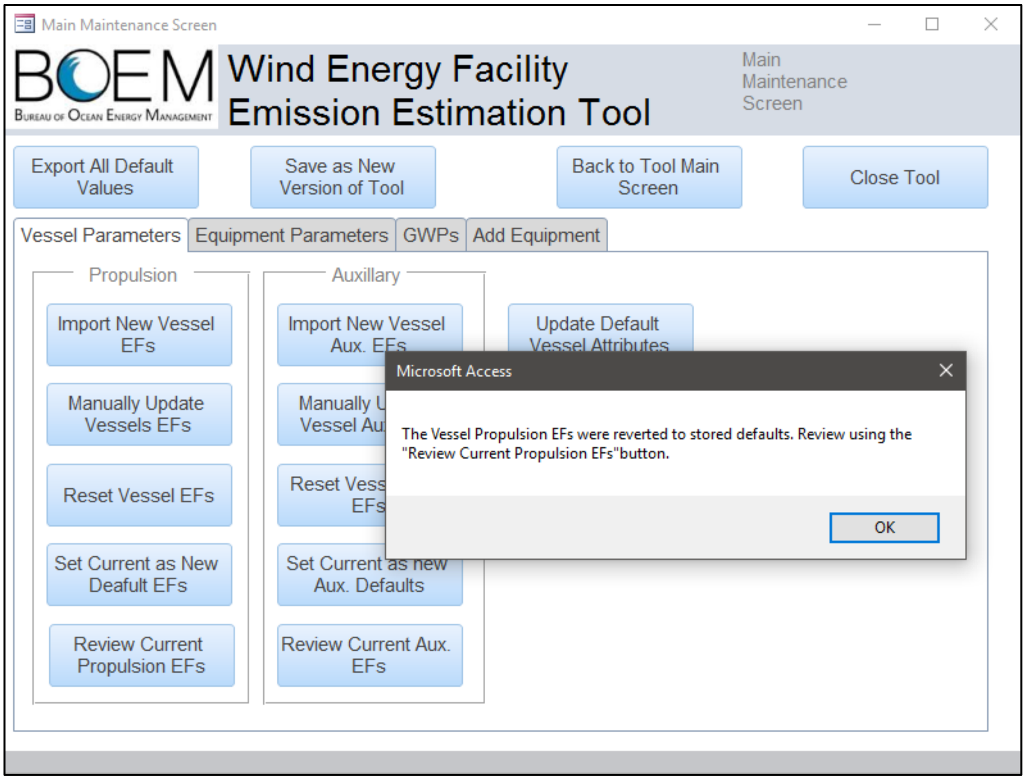


Figure 10. Pop-up message to indicate emission factors were reverted to the defaults

2.4 Set Current as New Default EF

The Maintenance screen provides the option to set the current emission factors as the defaults. This allows an update of the tool to new emission factors. This copy of the tool can be cleared and packaged for distribution as a new version (Section 6).

Clicking the “Set Current as New Default EF” button automatically initiates the code to set the current EFs as the default values. A pop-up window (Figure 11) opens when the process is complete and recommends reviewing the current factors using the appropriate “Review Current EF” button (Section 2.5).

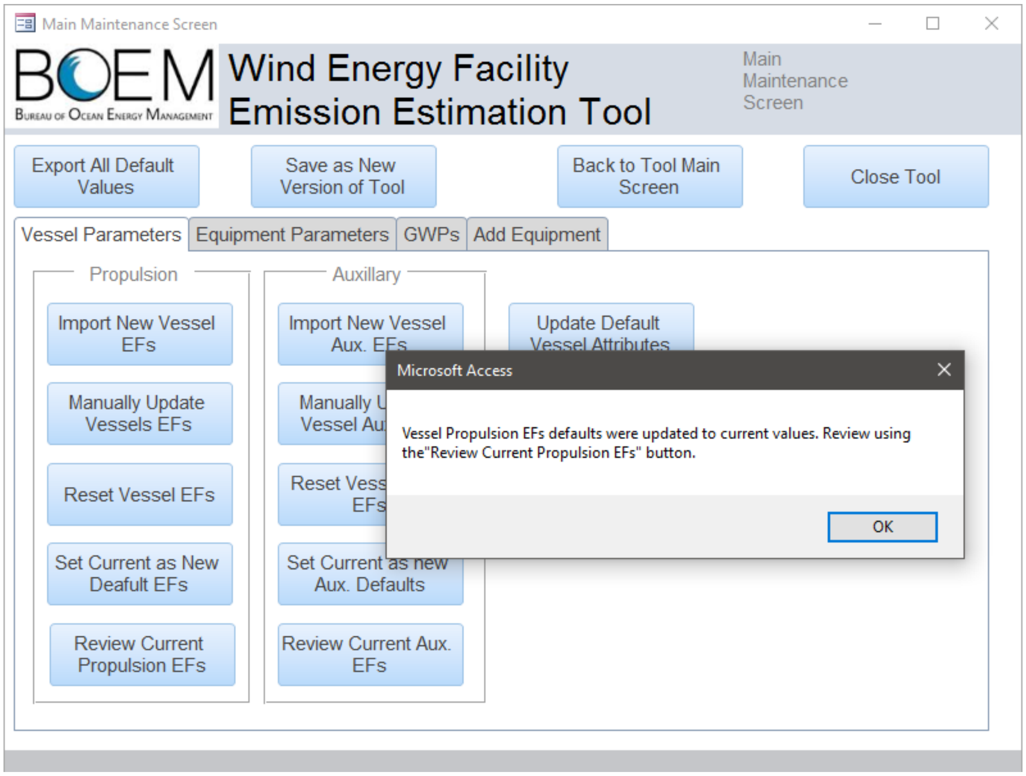


Figure 11. Pop-up indicating the current emission factors have been set as the defaults

2.5 Review Current EFs

Clicking the “Review Current EFs” button opens a separate window that lists all the emission factors for the source. The form can be closed by clicking the “Close Form” button at the top of the screen.

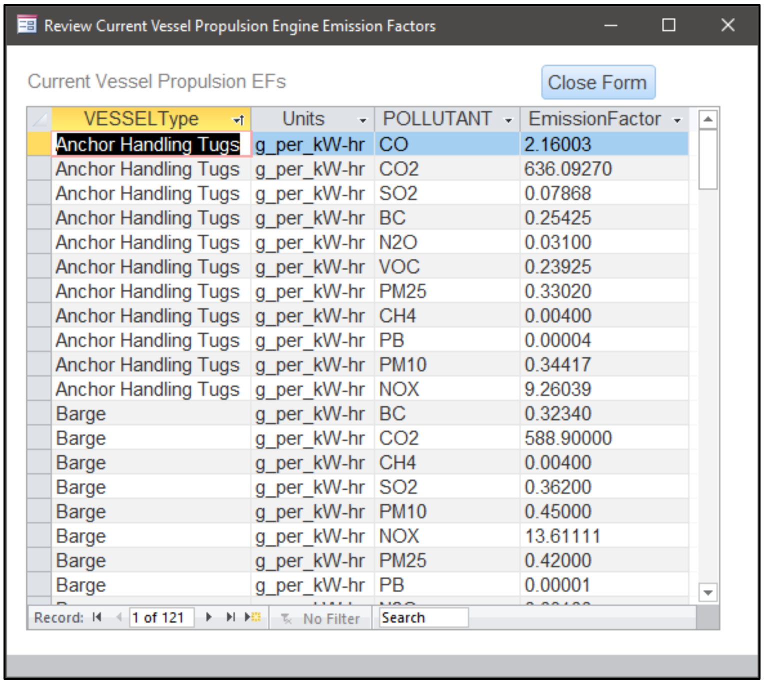


Figure 12. Review current emission factors screen

2.6 Update Default Attributes

The final option is the ability to change the values of the vessel defaults. The process is similar to manually editing the emissions factor, presented in Section 2.2:

1. Clicking the “Update Defaults Attributes” button opens a new window. (Figure 13)
2. The user selects the vessel type for the drop-down menu. (Figure 14)
3. The form is then populated with the values for the vessel type. (Figure 15)
4. The user can then edit the attributes in the lower boxes.
5. The user then clicks “save”, to save the change to a staging table and clear the form for additional edits.
6. Once all edits are made, the user clicks the “Review and Accept Changes” button to open a new window with a list of all the changes.
7. From here the user can:
    a. <u>Close form, without making changes</u>: Closes the review form without making changes, and returns to the “Update Defaults Attributes” screen to make more edits.
    b. <u>Make changes; return to make additional edits</u>: Saves the current list of changes, clears the list, and return the user to the “Update Defaults Attributes” screen to make more edits.
    c. <u>Make changes; return to Maintenance</u>: Saves the current list of changes, clears the list, and returns the user to the main “Maintenance” screen.
    d. <u>Make changes; return to make additional edits</u>: Saves the current list of changes, clears the list, and returns the user to the “Main” screen of the tool.

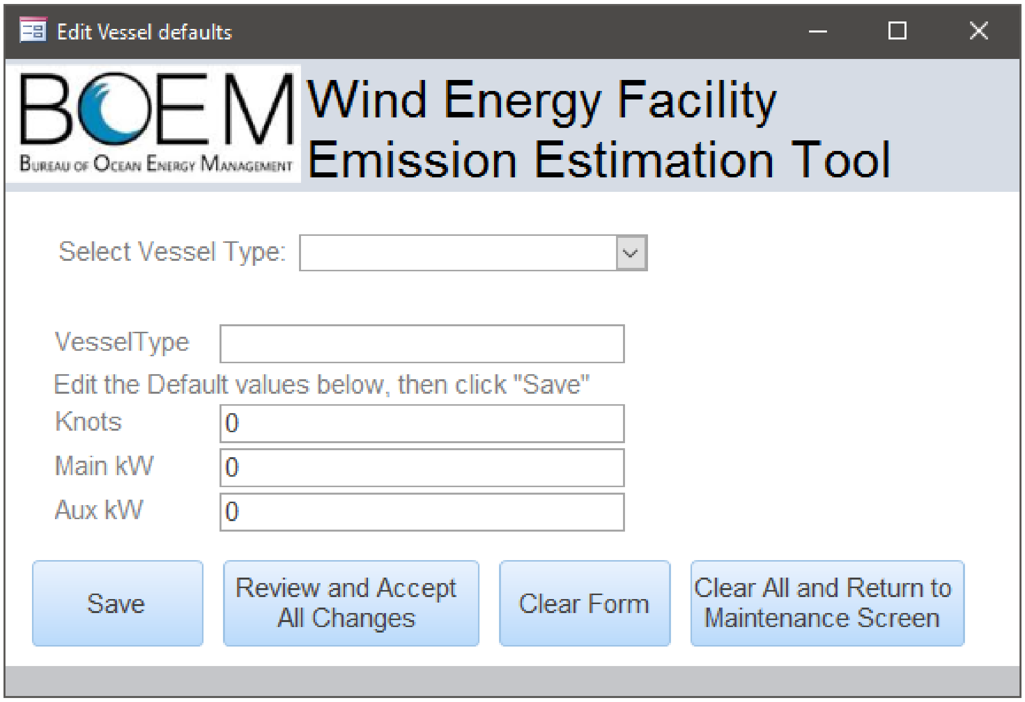


Figure 13. Editing vessel defaults screen

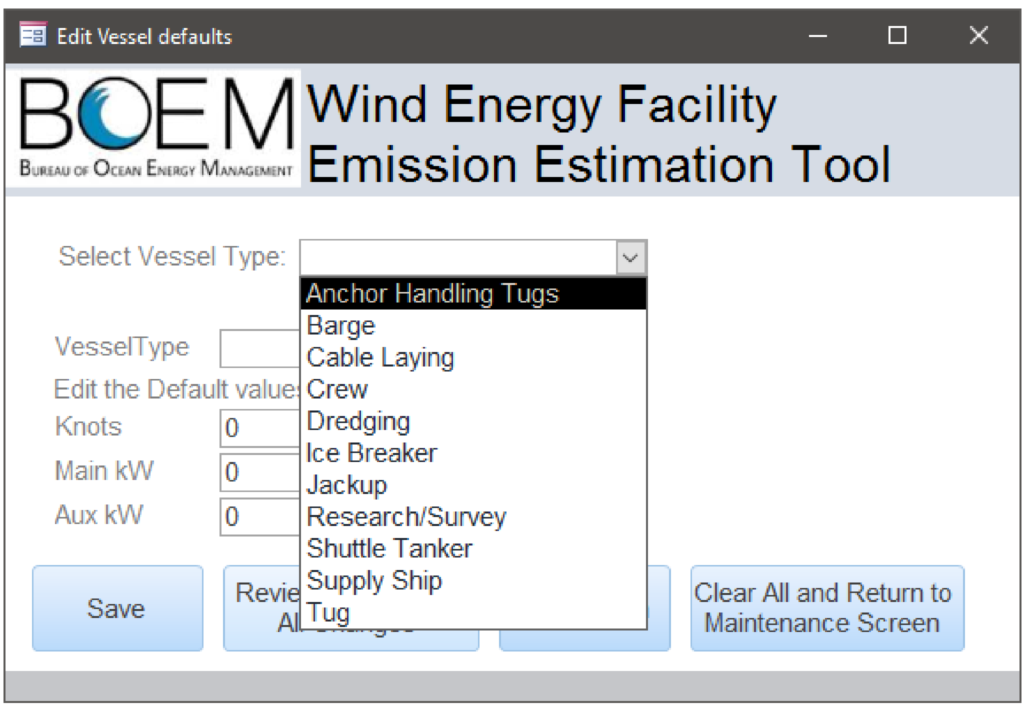


Figure 14. Vessel selection options for default edit screen

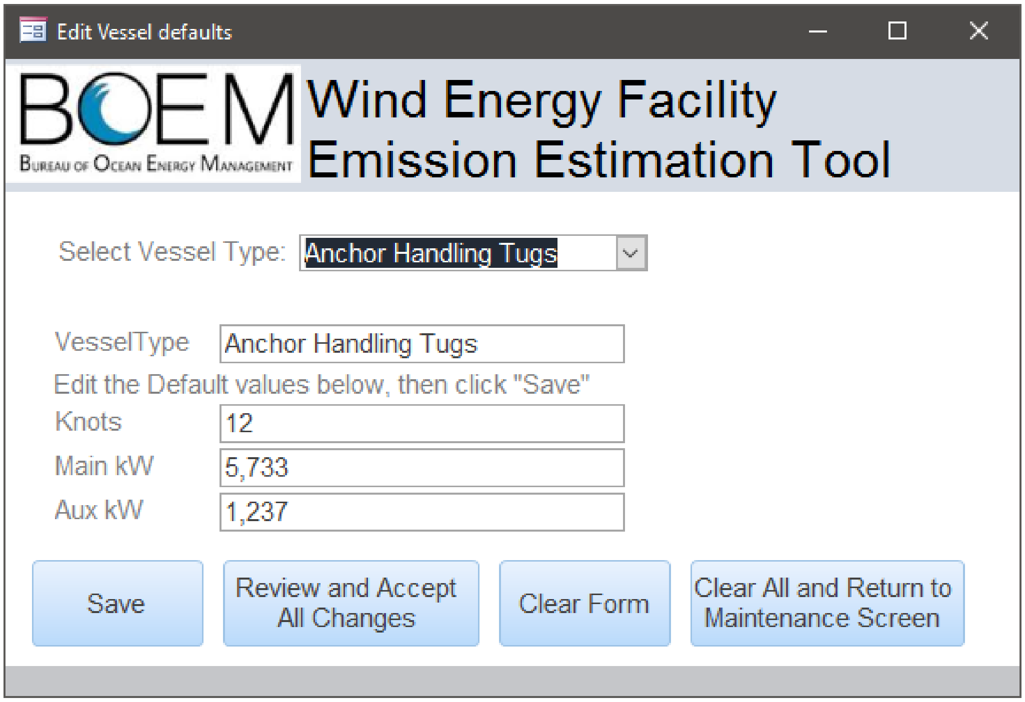


Figure 15. Populated default edit screen

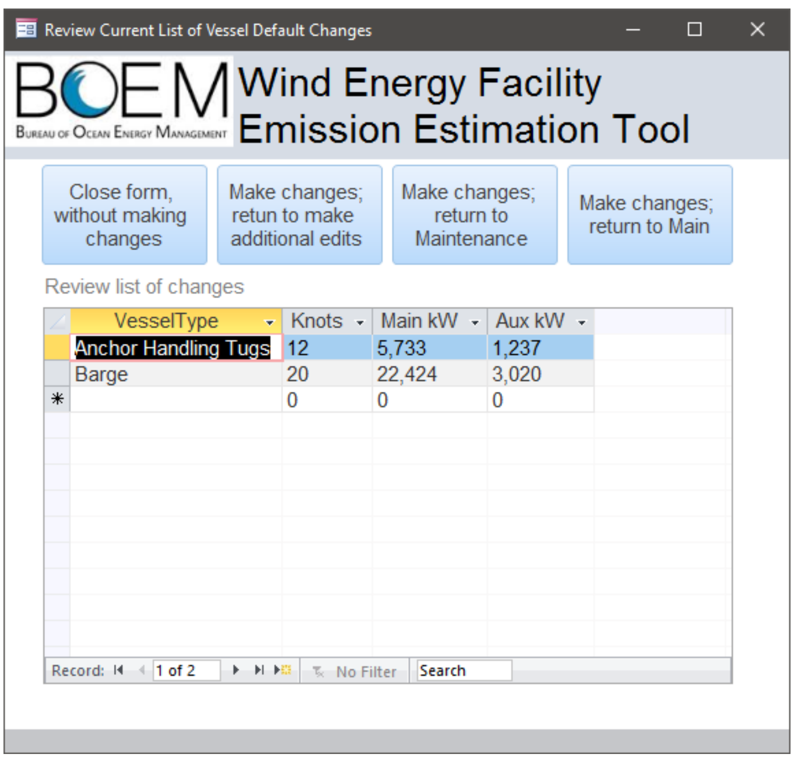


Figure 16. Review current list of default changes

3.0 Equipment Parameters Tab

The Equipment Parameters tab contains the update function for Helicopters, Substations, and Avoided emission. The function of each button is similar to the complementary versions on the Vessel Parameters tab. The differences in these screens will be discussed in the following sections.

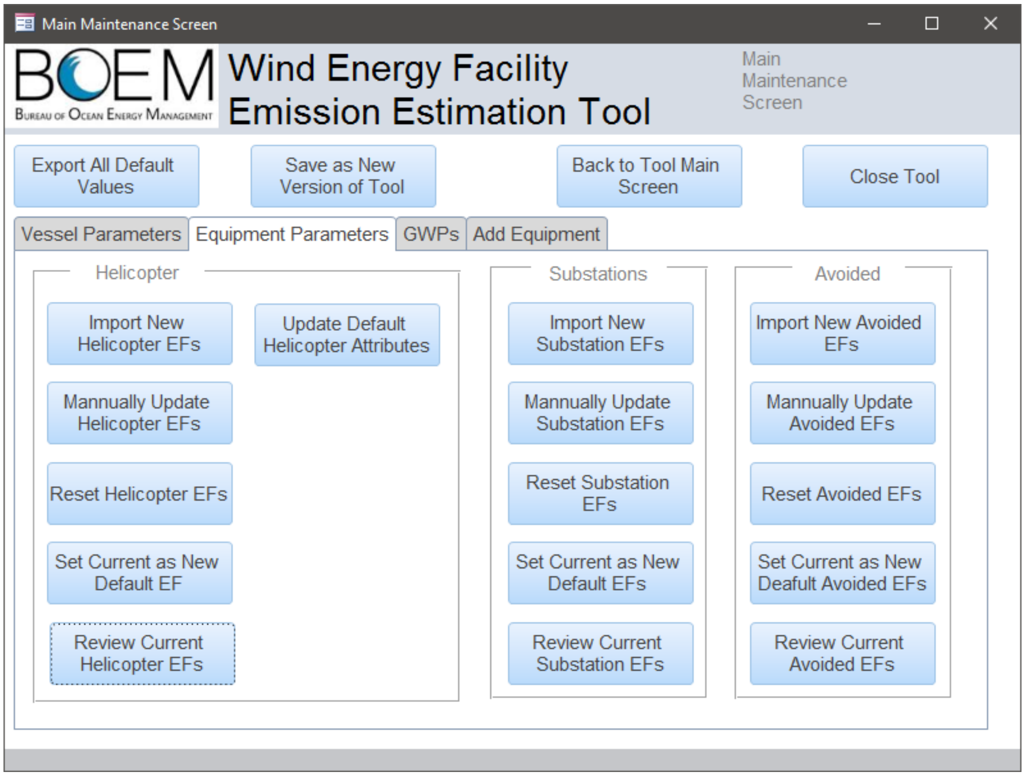


Figure 17. Equipment parameters tab

3.1 Helicopter

There are several maintenance options for the current and default emission factors:

- Import New EFs: Imports new EFs from a file. A template for emission factor imports is provided in the templates folder provided with the tool (\WindEneryTool_V1.0 - BOEMCopy\Maintenance_Templates\)
- Manually Update EFs: Manually changes the emission factors via form
- Reset EFs: Resets the emission factors to the saved default values
- Set Current as New Default EF: Replaces default EFs with the current emission factors
- Review Current EFs: Opens a window with the current EFs
- Update Default Helicopter Attributes: Opens a new window to edit the default vessel attributes

All the screens follow the same format as the vessel screens discussed in Section 2. Please see those section for the general process.

The only minor difference is the “Manually Update EF” and “Update Default Attribute” screens, which have a pulldown with the helicopter type (Figure 18).

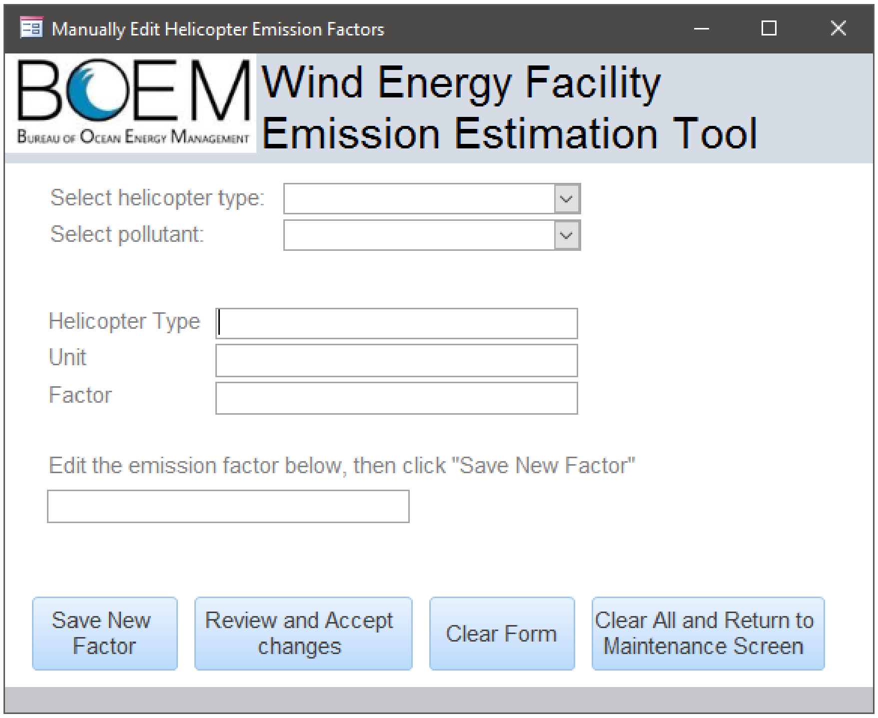


Figure 18. Helicopter manual edit screen

3.2 Substations

There are five maintenance options for the current and default substation emission factors:

- Import New EFs: Imports new EFs from a file. A template for emission factor imports is provided in the templates folder included with the tool (\WindEneryTool_V1.0 - BOEMCopy\Maintenance_Templates\)
- Manually Update EFs: Manually changes the emission factors via form
- Reset EFs: Resets the emission factors to the saved default values
- Set Current as New Default EF: Replaces default EFs with the current emission factors
- Review Current EFs: Opens a window with the current EFs

All the screen follows the same format as the vessel screens discussed in Section 2. Please see those section for the general process.

The only difference is with the “Manually Update EF”, which have multiple pulldowns associated with the engine type (Figure 19). Currently, the tool only has category 1 and 2 engines for regulatory tier 3 (Figure 20). This allows the specification of engine tier and category for further engine additions as technology changes. See Section 5 for more details on adding equipment.

There is no “Update Default Attribute” screen for substations.

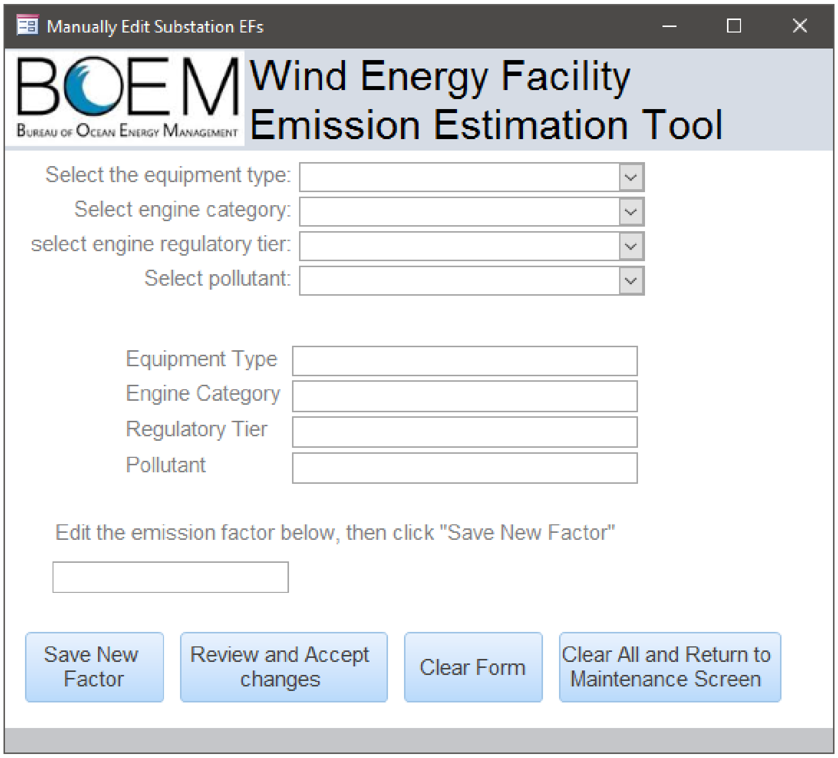
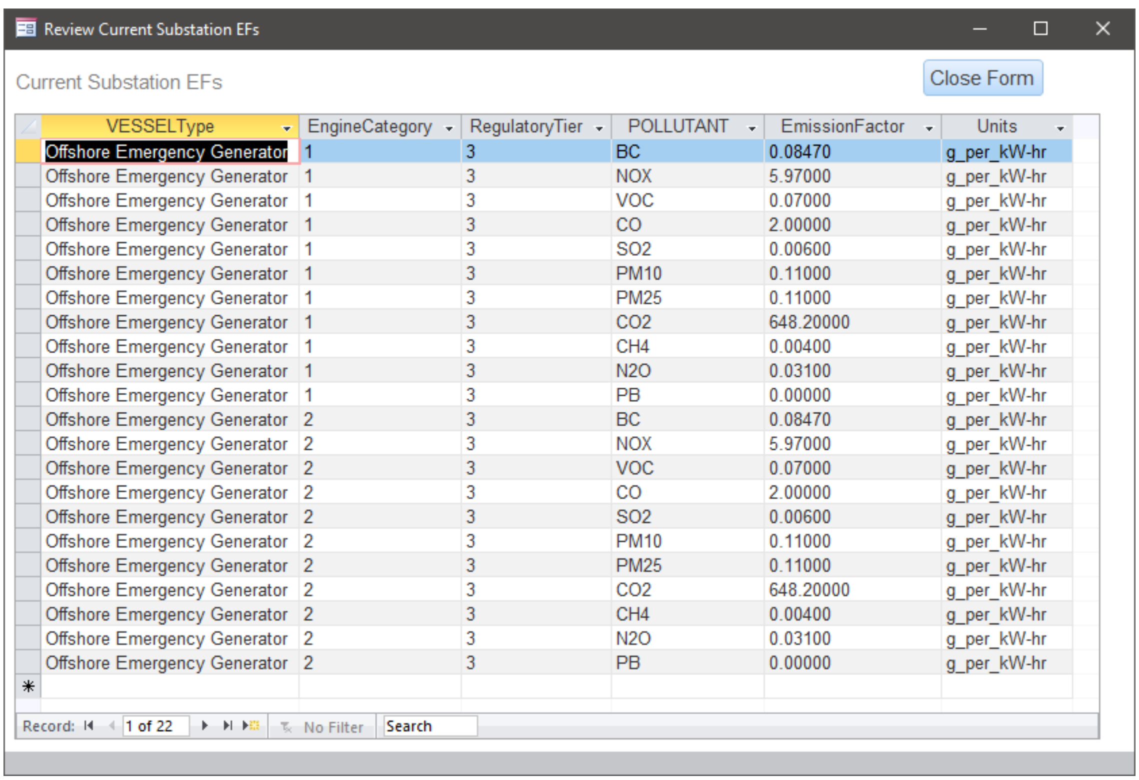


Figure 19. Substation manual entry screen



VESSELType	EngineCategory	RegulatoryTier	POLLUTANT	EmissionFactor	Units
Offshore Emergency Generator	1	3	BC	0.08470	g_per_kW-hr
Offshore Emergency Generator	1	3	NOX	5.97000	g_per_kW-hr
Offshore Emergency Generator	1	3	VOC	0.07000	g_per_kW-hr
Offshore Emergency Generator	1	3	CO	2.00000	g_per_kW-hr
Offshore Emergency Generator	1	3	SO2	0.00600	g_per_kW-hr
Offshore Emergency Generator	1	3	PM10	0.11000	g_per_kW-hr
Offshore Emergency Generator	1	3	PM25	0.11000	g_per_kW-hr
Offshore Emergency Generator	1	3	CO2	648.20000	g_per_kW-hr
Offshore Emergency Generator	1	3	CH4	0.00400	g_per_kW-hr
Offshore Emergency Generator	1	3	N2O	0.03100	g_per_kW-hr
Offshore Emergency Generator	1	3	PB	0.00000	g_per_kW-hr
Offshore Emergency Generator	2	3	BC	0.08470	g_per_kW-hr
Offshore Emergency Generator	2	3	NOX	5.97000	g_per_kW-hr
Offshore Emergency Generator	2	3	VOC	0.07000	g_per_kW-hr
Offshore Emergency Generator	2	3	CO	2.00000	g_per_kW-hr
Offshore Emergency Generator	2	3	SO2	0.00600	g_per_kW-hr
Offshore Emergency Generator	2	3	PM10	0.11000	g_per_kW-hr
Offshore Emergency Generator	2	3	PM25	0.11000	g_per_kW-hr
Offshore Emergency Generator	2	3	CO2	648.20000	g_per_kW-hr
Offshore Emergency Generator	2	3	CH4	0.00400	g_per_kW-hr
Offshore Emergency Generator	2	3	N2O	0.03100	g_per_kW-hr
Offshore Emergency Generator	2	3	PB	0.00000	g_per_kW-hr

Record: 1 of 22 No Filter Search

Figure 20. Current substation EF review screen

3.3 AVOIDED

Similar to substations, there are five maintenance options for the avoided emission factors:

- Import New EFs: Imports new EFs from a file. A template for emission factor imports is provided in the templates folder provided with the tool (\WindEneryTool_V1.0 - BOEMCopy\Maintenance_Templates\)
- Manually Update EFs: Manually changes the emission factors via form (Figure 21)
- Reset EFs: Resets the emission factors to the saved default values
- Set Current as New Default EF: Replaces default EFs with the current emission factors
- Review Current EFs: Opens a window with the current EFs (Figure 22)

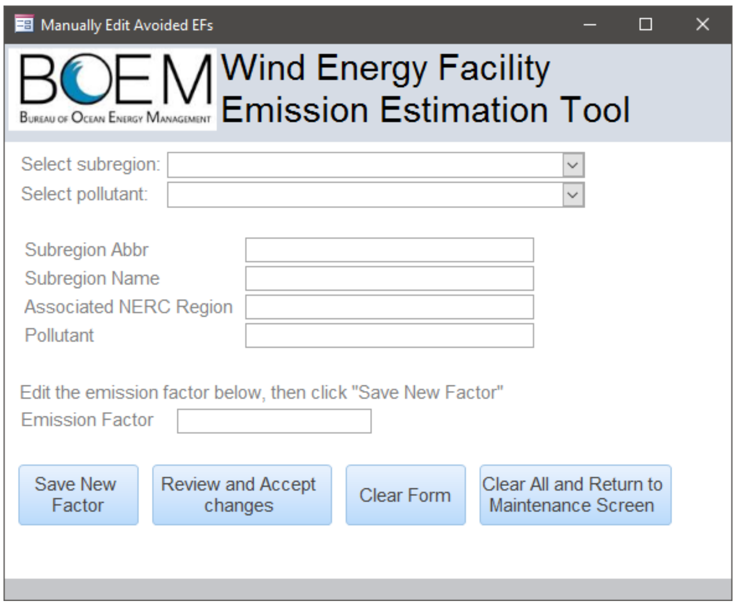
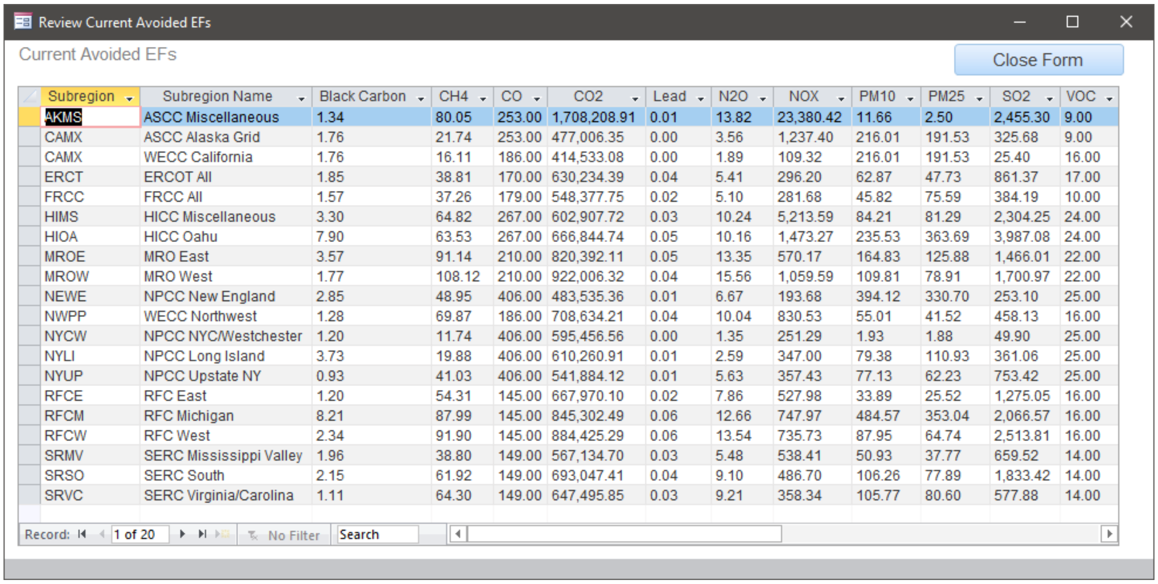


Figure 21. Avoided emission factor manual edit screen



Subregion	Subregion Name	Black Carbon	CH4	CO	CO2	Lead	N2O	NOX	PM10	PM25	SO2	VOC
AKMS	ASCC Miscellaneous	1.34	80.05	253.00	1,708,208.91	0.01	13.82	23,380.42	11.66	2.50	2,455.30	9.00
CAMX	ASCC Alaska Grid	1.76	21.74	253.00	477,006.35	0.00	3.56	1,237.40	216.01	191.53	325.68	9.00
CAMX	WECC California	1.76	16.11	186.00	414,533.08	0.00	1.89	109.32	216.01	191.53	25.40	16.00
ERCT	ERCOT All	1.85	38.81	170.00	630,234.39	0.04	5.41	296.20	62.87	47.73	861.37	17.00
FRCC	FRCC All	1.57	37.26	179.00	548,377.75	0.02	5.10	281.68	45.82	75.59	384.19	10.00
HIMS	HICC Miscellaneous	3.30	64.82	267.00	602,907.72	0.03	10.24	5,213.59	84.21	81.29	2,304.25	24.00
HIOA	HICC Oahu	7.90	63.53	267.00	666,844.74	0.05	10.16	1,473.27	235.53	363.69	3,987.08	24.00
MROE	MRO East	3.57	91.14	210.00	820,392.11	0.05	13.35	570.17	164.83	125.88	1,466.01	22.00
MROW	MRO West	1.77	108.12	210.00	922,006.32	0.04	15.56	1,059.59	109.81	78.91	1,700.97	22.00
NEWE	NPCC New England	2.85	48.95	406.00	483,535.36	0.01	6.67	193.68	394.12	330.70	253.10	25.00
NWPP	WECC Northwest	1.28	69.87	186.00	708,634.21	0.04	10.04	830.53	55.01	41.52	458.13	16.00
NYCW	NPCC NYC/Westchester	1.20	11.74	406.00	595,456.56	0.00	1.35	251.29	1.93	1.88	49.90	25.00
NYLI	NPCC Long Island	3.73	19.88	406.00	610,260.91	0.01	2.59	347.00	79.38	110.93	361.06	25.00
NYUP	NPCC Upstate NY	0.93	41.03	406.00	541,884.12	0.01	5.63	357.43	77.13	62.23	753.42	25.00
RFCE	RFC East	1.20	54.31	145.00	667,970.10	0.02	7.86	527.98	33.89	25.52	1,275.05	16.00
RFCM	RFC Michigan	8.21	87.99	145.00	845,302.49	0.06	12.66	747.97	484.57	353.04	2,066.57	16.00
RFCW	RFC West	2.34	91.90	145.00	884,425.29	0.06	13.54	735.73	87.95	64.74	2,513.81	16.00
SRMV	SERC Mississippi Valley	1.96	38.80	149.00	567,134.70	0.03	5.48	538.41	50.93	37.77	659.52	14.00
SRSO	SERC South	2.15	61.92	149.00	693,047.41	0.04	9.10	486.70	106.26	77.89	1,833.42	14.00
SRVC	SERC Virginia/Carolina	1.11	64.30	149.00	647,495.85	0.03	9.21	358.34	105.77	80.60	577.88	14.00

Figure 22. Screen to review current avoided emission factors

4.0 GWP Tab

The "GWP" tab (Figure 23) contains buttons to perform several maintenance and testing features for the global warming potentials used in emission calculations. Similar to the emissions factors, Default values are held in a separate table to allow a quick reset of the tool. Active values used for calculations are held in a separate table to allow easy testing of revised values.

- Import new GWPs: Allows BOEM the ability to import new GWPs from a file to the tool for testing. This does not replace the default values.
- Manually Update GWPs: Opens a separate window that allows BOEM the ability to edit GWPs one at a time for testing. New window has the option to set these new values as the new default.
- Revert to default GWPs: Will revert the active table values to the default values, that will allow the user to return to default after testing revised factors.
- Import new GWPs defaults: Allows BOEM the ability to import new GWPs from a file to the default table. Updates both the default and active table.
- Review Current GWPs: Views the GWPs currently used by the Wind Energy Tool for calculations.

The function of each button is similar to the complementary versions on the Vessel and Equipment Parameters tab. The differences in these screens will be discussed in the following sections.

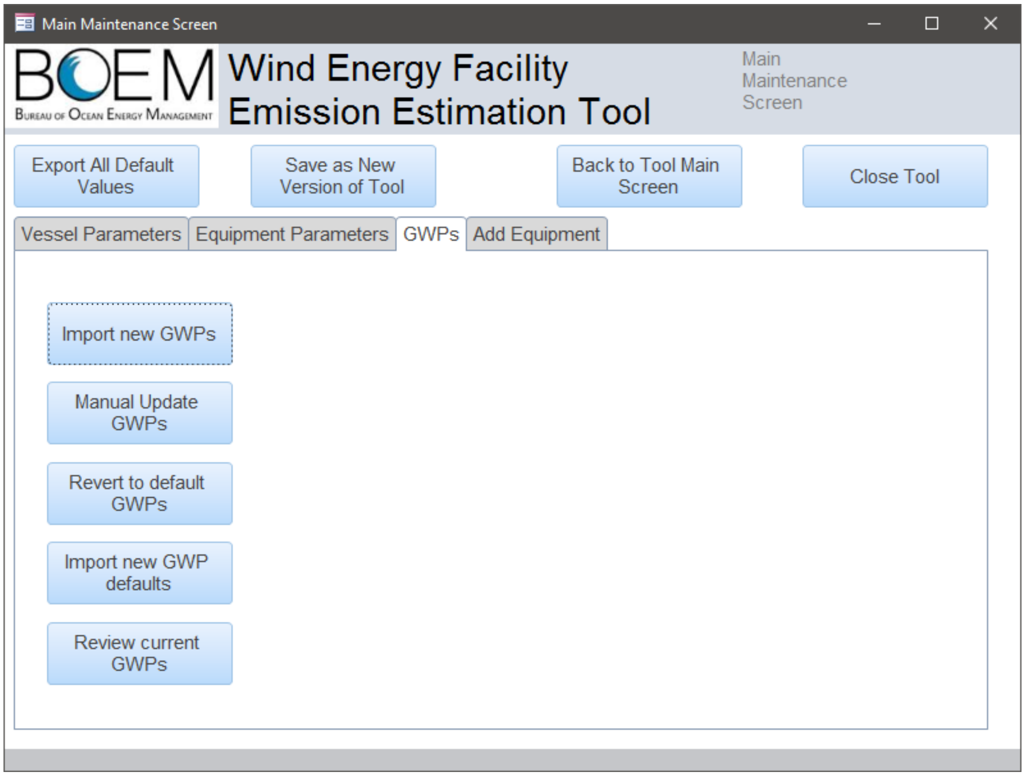


Figure 23. Wind energy tool main maintenance screen, GWP tab

4.1 Import New GWPs

New GWPs can be imported from a file to the current table to allow testing of new values. A template for GWP import is provided in the templates folder provided with the tool (\WindEneryTool_V1.0 - BOEMCopy\Maintenance_Templates\).

Clicking the button opens a window to navigate to the file for import. After a file is selected, the tool automatically imports the table. A pop-up window opens once the file is imported (Figure 24) and recommends reviewing the imported GWPs using the “Review Current GWPs” button (Section 4.5), to ensure values were imported properly.

If BOEM wants to make these values the new defaults, they would need to click the “Import New GWP Defaults” button. Further instructions are in Section 4.4.

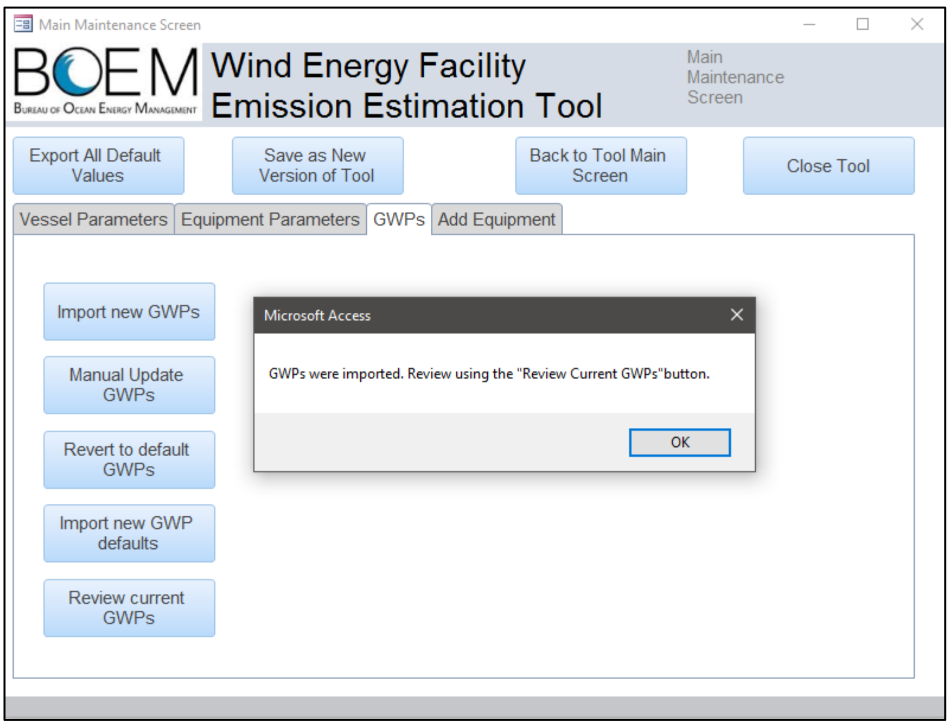


Figure 24. A pop-up appears to note new GWPs were imported

4.2 Manually Update GWPs

The second option on the maintenance screen is to manually change the current emission factors. Clicking the “Manually Update EFs” button opens a separate window (Figure 25) where the user can cycle through the pollutants, and update the GWP in the “Global Warming Potential” box toward the bottom of the screen. Click “Save Record” to save the edit in a staging table.

Once all edits are completed, the user has two save option:

- Save and Return to Maintenance Screen: saves the changes to the current GWP table only, closes the Manual Updates screen, and returns to the “Maintenance” screen.

- Make changes; return to make additional edits: saves the changes to the current and default GWP table, closes the Manual Updates screen, and returns to the "Maintenance" screen.

All pollutants are included in the list, to simplify calculations and allow for the inclusion of additional greenhouse gas pollutants in the future.

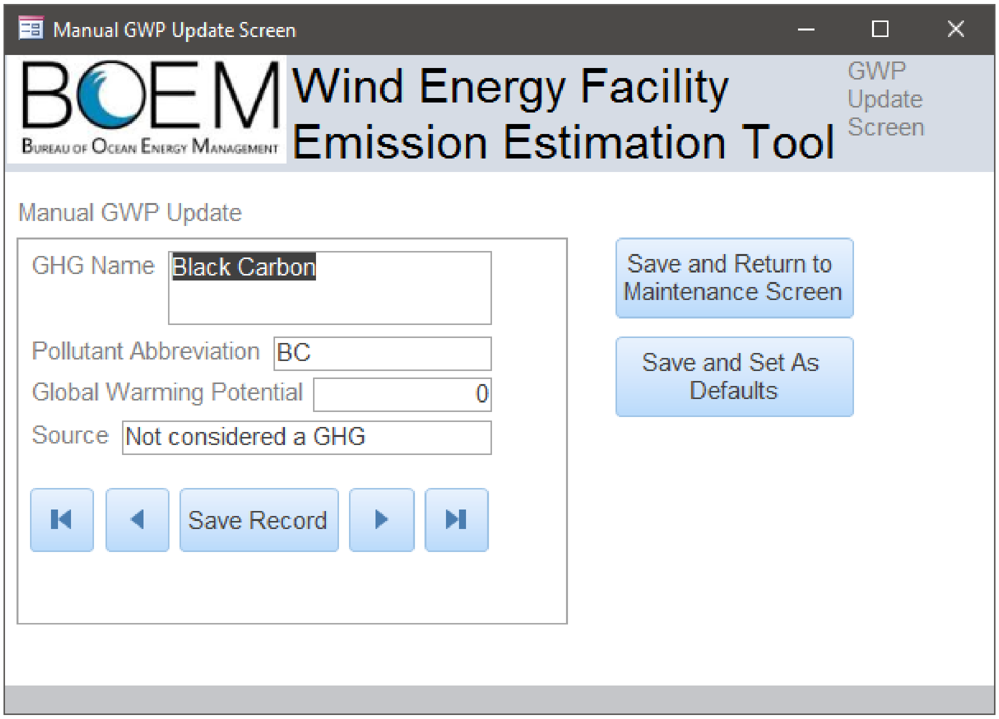


Figure 25. Manual GWP update screen

4.3 Revert to Default GWPs

The Maintenance screen provides the option to revert the current GWPs back to the saved defaults. This allows the return of the personal copy of the tool back to the initial state after testing the implications of changes to the GWPs.

Clicking the "Revert to Default GWPs" button automatically initiates the code to reset the current GWPs to the default values. A pop-up window (Figure 26Figure 10) opens when the process is complete, and recommends reviewing the current factors using the appropriate "Review Current EF" button (Section 4.5).

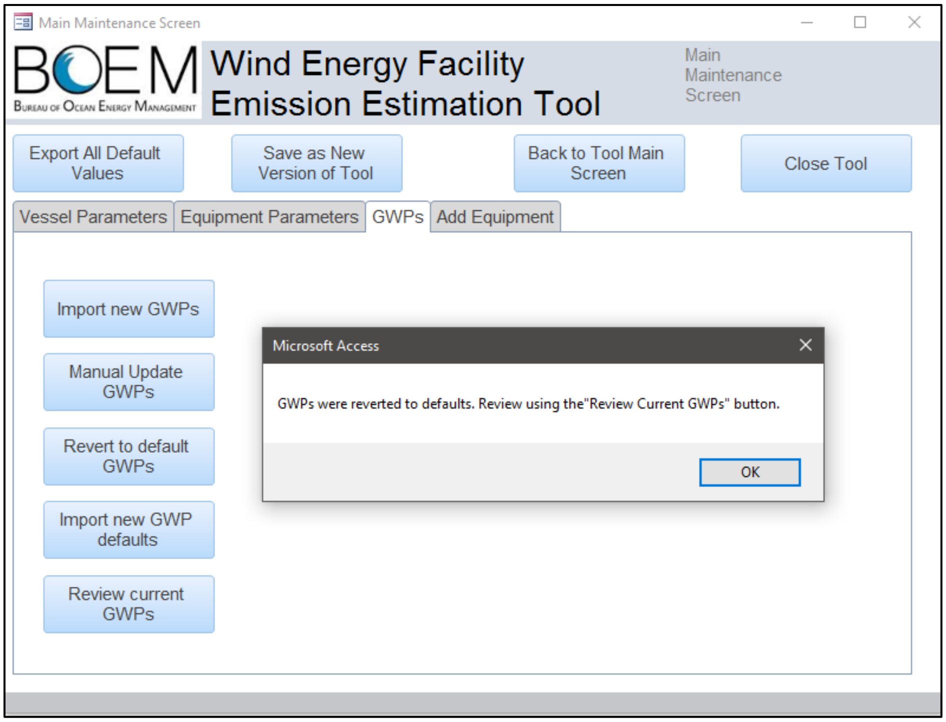


Figure 26. A pop-up appears to note the GWPs were reverted to default values

4.4 Import New GWPs

New GWPs can be imported from a file to the current table and default table at the same time. Clicking the "Import New GWP defaults" button opens a window to navigate to the file for import. After a file is selected, the tool automatically imports the table. A pop-up window opens once the file is imported (Figure 27) and recommends reviewing the imported GWPs using the "Review Current GWPs" button (Section 4.5), to ensure values were imported properly.

Again, a template for GWP import is provided in the templates folder provided with the tool (\WindEneryTool_V1.0 - BOEMCopy\Maintenance_Templates\).

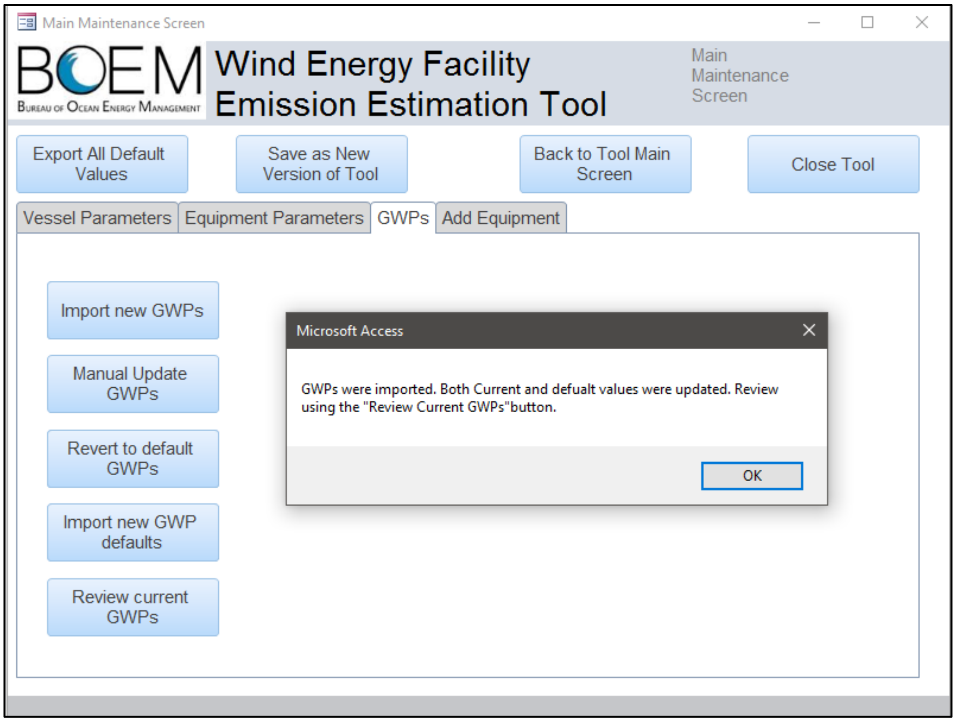
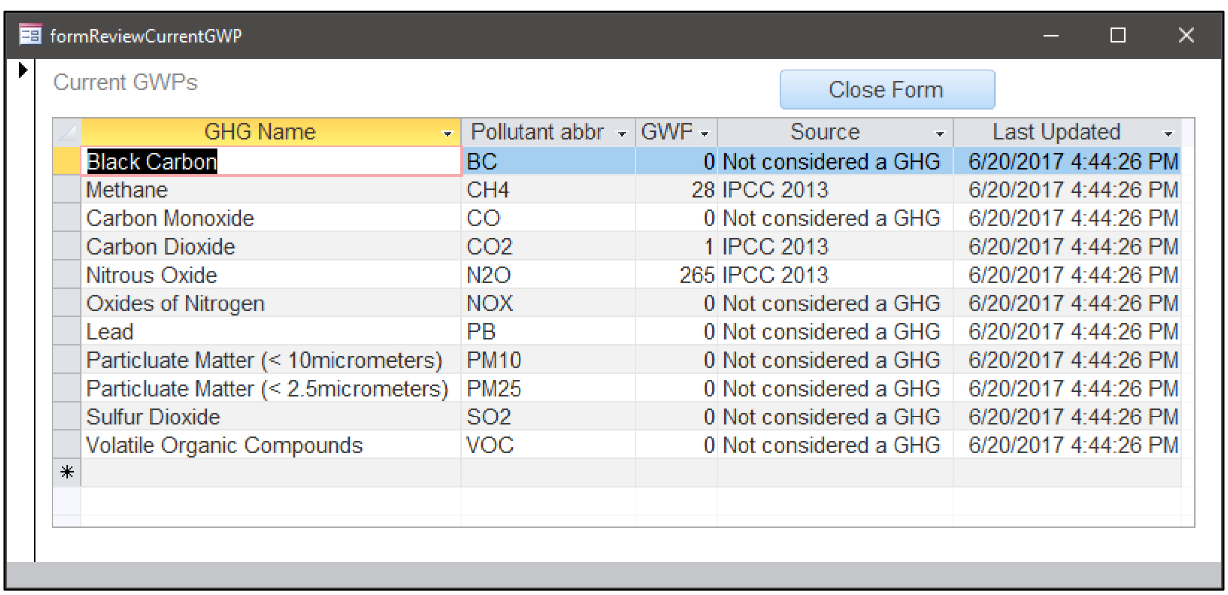


Figure 27. A pop-up appears to note the current and default GWPs were updated

4.5 Review Current GWPs

The last button on the GWP tab allows the user to review the current GWPs. Clicking this button opens a new window with a list of the GWP for all pollutants (Figure 28). Again, all pollutants are included in the list, to simplify the coding of calculations and allow for the inclusion of additional greenhouse gas pollutants at a future date.



GHG Name	Pollutant abbr	GWP	Source	Last Updated
Black Carbon	BC	0	Not considered a GHG	6/20/2017 4:44:26 PM
Methane	CH4	28	IPCC 2013	6/20/2017 4:44:26 PM
Carbon Monoxide	CO	0	Not considered a GHG	6/20/2017 4:44:26 PM
Carbon Dioxide	CO2	1	IPCC 2013	6/20/2017 4:44:26 PM
Nitrous Oxide	N2O	265	IPCC 2013	6/20/2017 4:44:26 PM
Oxides of Nitrogen	NOX	0	Not considered a GHG	6/20/2017 4:44:26 PM
Lead	PB	0	Not considered a GHG	6/20/2017 4:44:26 PM
Particluate Matter (< 10micrometers)	PM10	0	Not considered a GHG	6/20/2017 4:44:26 PM
Particluate Matter (< 2.5micrometers)	PM25	0	Not considered a GHG	6/20/2017 4:44:26 PM
Sulfur Dioxide	SO2	0	Not considered a GHG	6/20/2017 4:44:26 PM
Volatile Organic Compounds	VOC	0	Not considered a GHG	6/20/2017 4:44:26 PM

Figure 28. Current GWP review screen

5.0 Add Equipment Tab

Another maintenance feature of the Wind Energy Tool is the ability for BOEM to add additional vessel, helicopter, and substation types as the tool matures. The “Add Equipment” tab (Figure 29) has a three button that open windows (Figure 30) to add new vessel, helicopter, and substation types. All three entry screens are laid out similarly to standardize the process of adding equipment types.

To add a new equipment type:

1. Clicking the “Add New Type” button opens a new window (Figure 30)
2. The user can import or manually enter the new type
    a. Importing:
        i. Clicking the import button open a window to navigate to the file for import. Templates are provided in the template folder (Updated_Add_Vessel_Type_Template.xlsx, Updated_Add_helicopter_Type_Template.xlsx, Updated_Add_Substation_Type_Template.xlsx)
        ii. Once the file is selected the data is automatically imported in to the staging tables. The user can review the data by clicking the “Review and Accept Changes” button (see step 3)
    b. Manual Entry:
        i. Enter the values in the fields provided, including emission factors for each pollutant listed in the table.
        ii. When done click “save”, to save the change to a staging table and clear the form for additional edits.
        iii. Once all edits are made, the user clicks the “Review and Accept Changes” button to open a new window (Figure 33) with a list of all the changes. (See step 3)
3. Once the “Review and Accept Changes” window (Figure 33) is open, the user can:
    a. Close form, without making changes: Closes the review form without making changes, and returns to the “Update Defaults Attributes” screen to make more edits.
    b. Make changes; return to make additional edits: Adds the new types to the current and default tables, clears the list, and returns the user to the “Update Defaults Attributes” screen to make more edits.
    c. Make changes; return to Maintenance: Adds the new types to the current and default tables, clears the list, and returns the user to the main “Maintenance” screen.
    d. Make changes; return to make additional edits: Adds the new types to the current and default tables, clears the list, and returns the user to the “Main” screen of the tool.

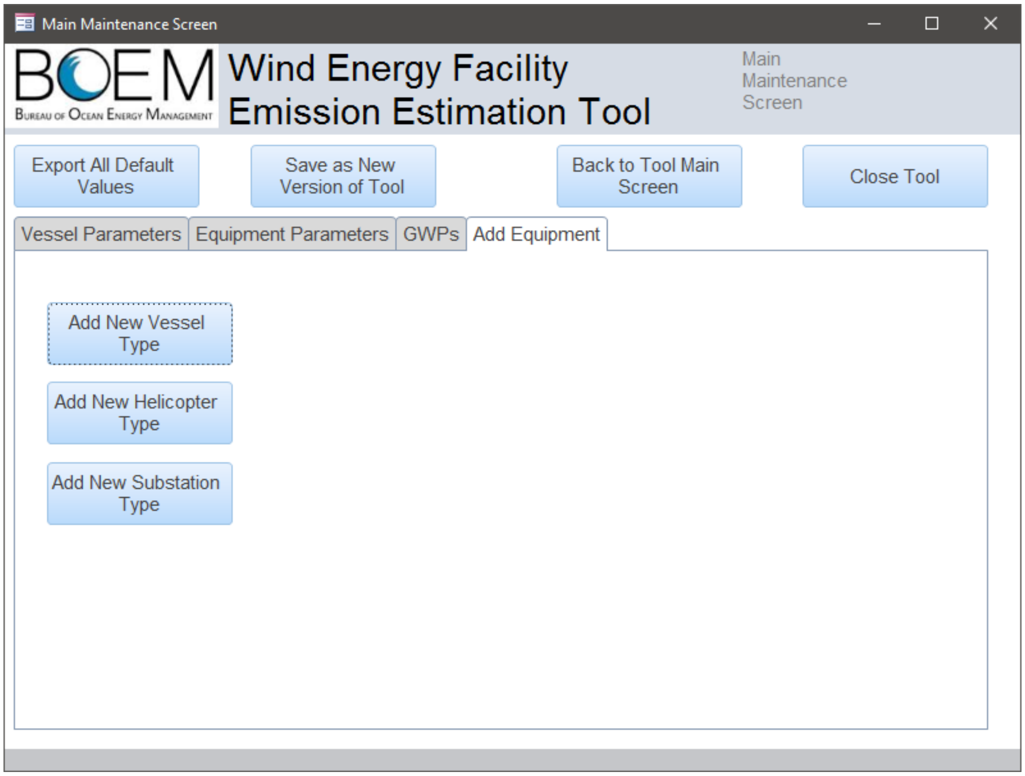


Figure 1. Add equipment tab

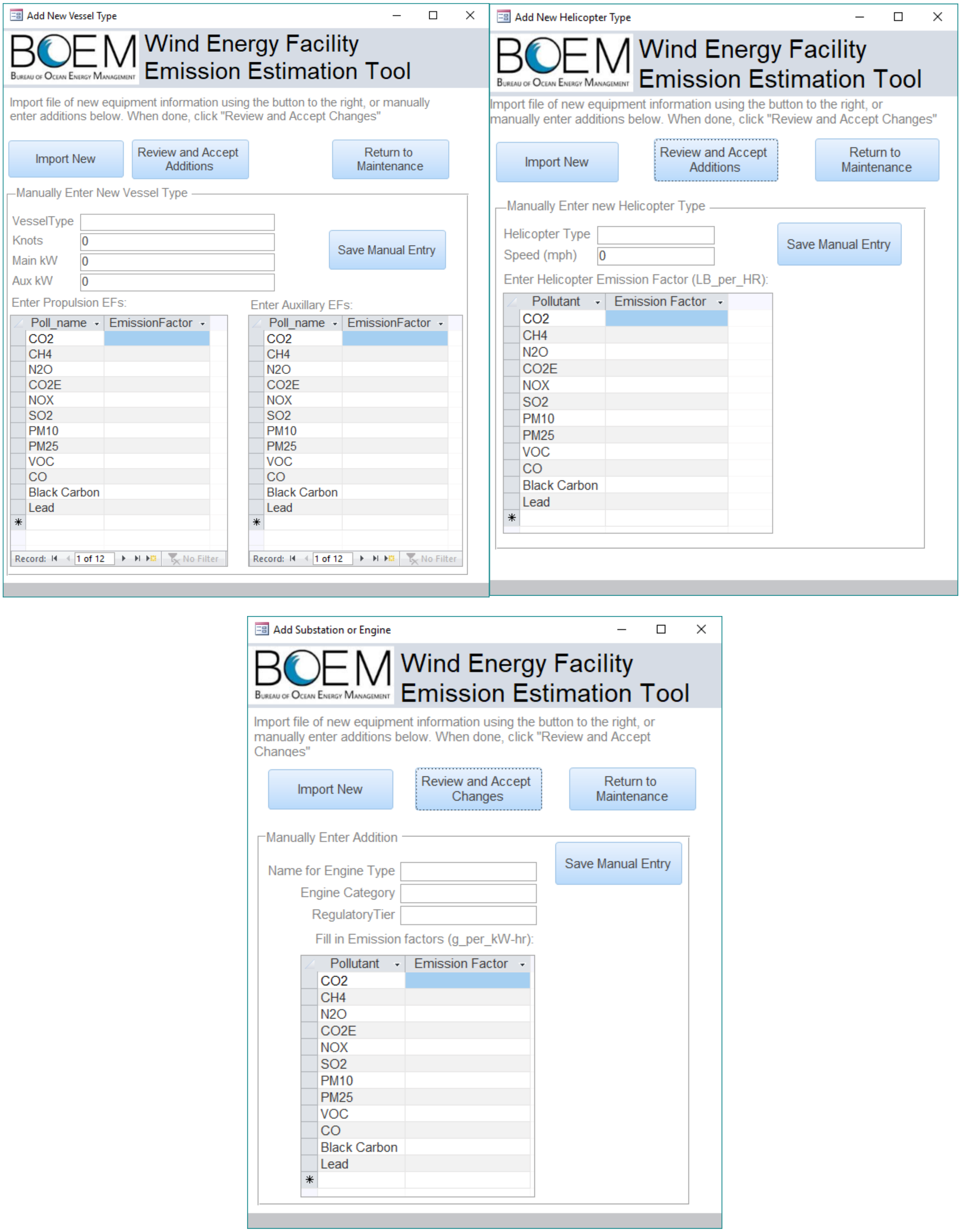


Figure 30. Vessel (top left), helicopter (top right), and substation (bottom, center) add screens

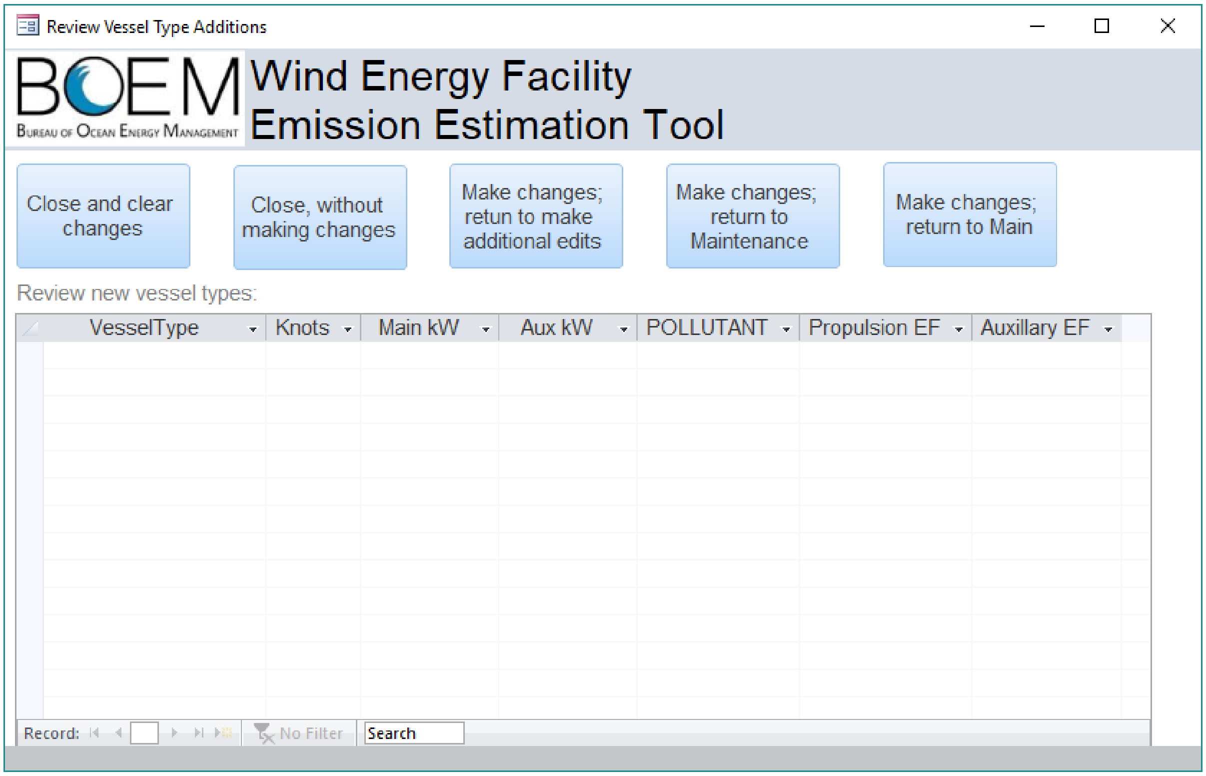


Figure 31. Review screen

6.0 Save New Version of Tool

To simplify distribution of revised version of the tool, the Wind Energy Tool is equipped with a button to save a new copy of the tool. The "Save as New Version of Tool" located at the top of the Maintenance Screen (Figure 32). Clicking the button opens a Window to browse to a location to save the file. The default save location is the same directory as the open tool. The file name and location can be changed as desired. Once "save" is clicked, the screen flashes up the new database name and location, clearing any saved project data and compressed the database. A pop-up window (Figure 34) will appear to let the user know the export process has completed.

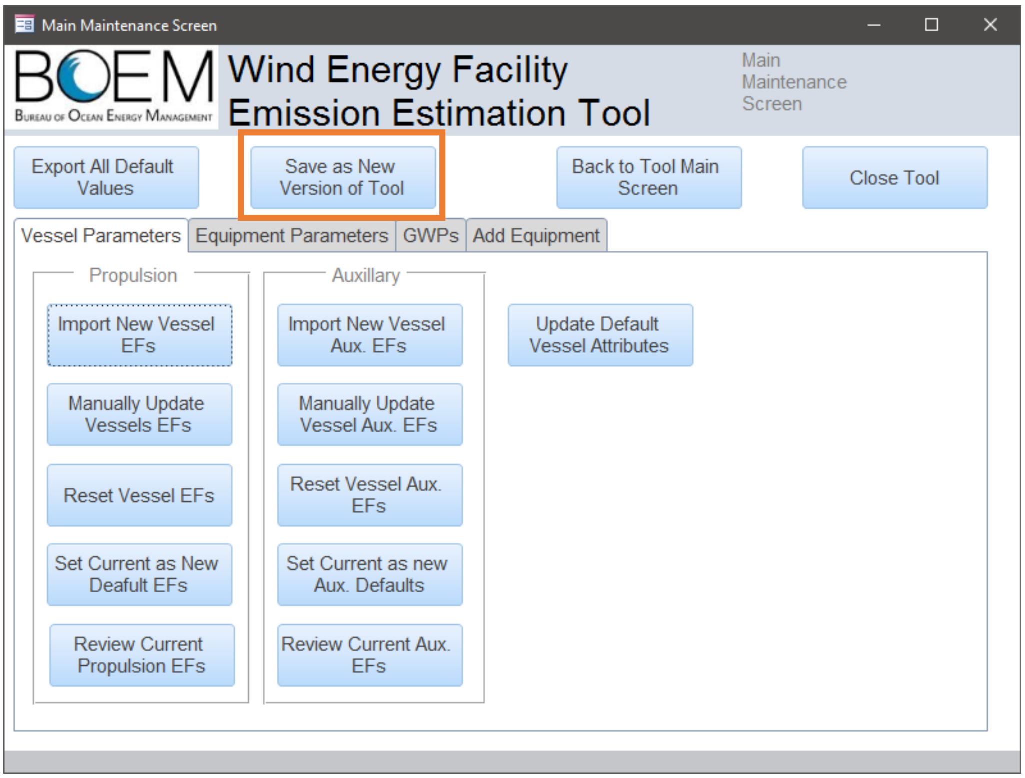


Figure 32. Maintenance screen, with save as new version button highlighted in orange

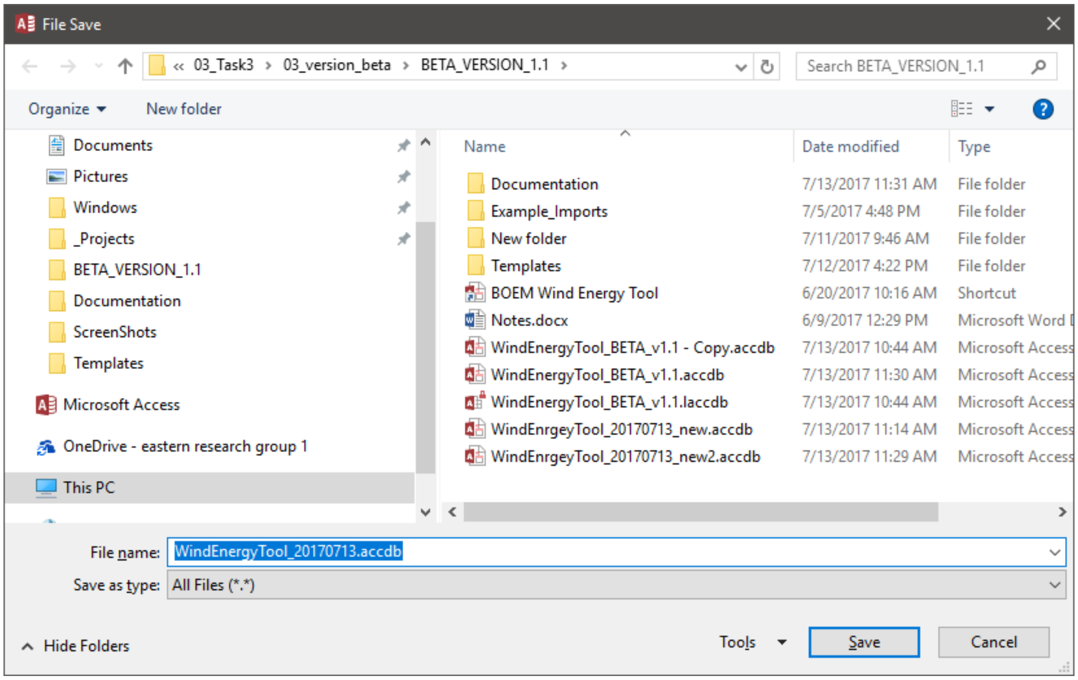


Figure 33. New tool save window

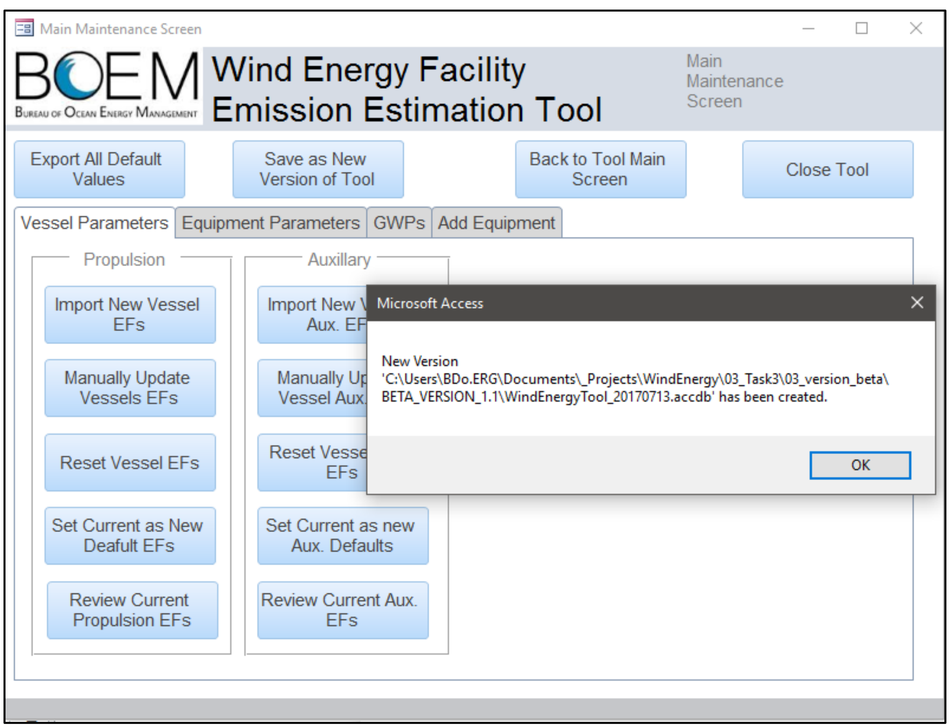


Figure 34. A pop-up indicates the new version of the tool was saved