IMPLEMENTATION GRANT APPLICATION TECHNICAL APPENDIX

This technical appendix explains the methodology and assumptions used for developing the estimated GHG emissions and co-pollutant emissions reduced as a result of the investments in OSW resources described in this proposal. The "GHG Emission Reduction Calculation Spreadsheet" included with this application provides the specific GHG emission reduction calculations for each measure.

Emission Reductions Estimate Method

To estimate emissions reductions, the states have used Emissions reductions are calculated using the 2022 total output emissions rates, shown in Table 1, from EPA's eGRID dataset for the NEWE subregion for CO_2e, NOx, and SO_2.[1]

Table 1. 2022 EPA eGRID emissions rates for Total Output and Non-baseload.

Emissions Rate	CO_2e lbs/MWh	SO_2 lbs/MWh	NOx lbs/MWh	OS-NOx lbs/MWh
Total Output	540.5	0.122	0.309	0.283
Non-baseload	928.1	0.249	0.457	0.329

The electricity generated by a wind or solar project in a particular state may not necessarily displace electricity that would have been generated within the same state. For example, a wind farm in Iowa may displace fossil generation in Minnesota. For this analysis, emissions rates at the EPA eGRID subregion level are used. According to EPA, the subregion emission rates most accurately represent the actual electricity used by consumers by limiting the import and export of electricity within an aggregated area. The subregions were defined by EPA as a compromise between North American Electric Reliability Corporation (NERC) regions (which EPA felt were too big) and balancing authorities (which EPA felt were generally too small). In some cases, a state lies within one subregion but in many cases, multiple subregions intersect a state. As it is unclear to which subregion a plant located in a particular state provides electricity, state-level emissions rates were calculated by taking an area-weighted average of the subregions intersecting each state.

a. Models/Tools Used

Considering that FOSW in the Gulf of Maine will serve the entire New England Region through points of interconnection (POIs) into multiple states bordering the Gulf (Maine, New Hampshire, Massachusetts) between the long-term timeframe of 2025-2050, this proposal has adopted a bespoke model that is developed numerically in the accompanying spreadsheet workbook. This model workbook, or workbook, contains 10 worksheets (sheets) described later in this appendix.

[1] https://www.epa.gov/egrid

The model considers the estimated future peak load demand (57 GW) and generation mix (97.2 GW) for the New England subregion according to the ISO-NE 2050 Transmission Study (ISO-NE Study).[2] The model identifies FOSW deployment numbers according to targets identified by the partner states and develops an assessment of the 21.1 percent contribution that FOSW is expected to make to the 2050 electricity generation resource mix as shown in Table 2.[3]

The model develops deployment rates for FOSW between 2025 and 2050 for cases with and without an EPA CPRG award and calculates cumulative annual emissions based on the difference between these two cases and annual decrements in emissions reductions coefficients based on the assumption that FOSW is the only contribution to a cleaner grid. Note that the model identifies 2049 as the last year of the time period in question, understanding that the time period ends on December 31, 2049 and targets are met by January 1, 2050. This definition of time period allows for a 5-year increment from 2025-2030, a 10-year increment from 2030-2040, and a 10-year increment from 2040-2050.

Table 2. Estimated NEWE Grid Generation Mix in 2050 per ISO-NE Transmission Study (Figure 1.2 on Page 12). See Sheet 8 of the model workbook.

Resource	GW	CF	TWh	% Total
Solar	57	0.25	124.8	46.2%
OSW	19	0.45	74.9	27.7%
FOSW	13	0.50	56.9	21.1%
Land Based Wind	3	0.35	9.2	3.4%
Storage	5.2	0.10	4.6	1.7%
Total	**97.2**	**0.318**	**270.4**	**100%**

Based on these numbers, the model estimates that emissions rates for CO_2e, for instance, diminish from 540.5 lbs/MWh in 2022 to 427.7 lbs/MWh in 2049. Annual decrements in emissions rates are assumed to be proportional to the annual increment of additional FOSW coming online under the case where the EPA-CPRG is awarded.

b. Measure Implementation Assumptions

This section identifies the key assumptions about measure implementation were used to quantify emissions reductions for this measure. The section in the attached 10-sheet workbook on a sheet-by-sheet basis, listing key assumptions on each sheet. Explanations of these assumptions are also provided within each sheet in the workbook.

[2] ISO-NE. 2024. 2050 Transmission Study. February 12. https://www.iso-ne.com/static-assets/documents/100008/2024_02_14_pac_2050_transmission_study_final.pdf

[3] Note that the ISO-NE Study identifies 32 GW of offshore wind, without distinguishing between fixed bottom (shallow water) and floating (deep water) offshore wind. This model adopts the state targets of 3 GW for Maine and 10 GW for Massachusetts for the total of 13 GW of FOSW that appears in Table 2, leaving the remaining 19 GW of OSW to be understood as fixed bottom to the south of Cape Cod.

Sheets 1 through 7

Sheets 1 through 7 calculate the estimated differential in FOSW deployment for cases with and without a CPRG Award. The Chart associated with Sheet 6 (and provided on its own sheet) represents graphically the results of this deployment analysis. Sheet 7 provides emissions reduction estimates based on the deployment analysis provided in Sheets 1-6.

Sheet 1: Searsport Fixed Offshore Wind Turbine (OWT) deployments with EPA Award

- Searsport assists fixed OWT deployment starting in 2028 with ten 15 MW OWTs.
- Searsport expands to thirteen 15 MW fixed OWTs in 2029.
- Total fixed OWT deployment out of Searsport reaches 345 MW in 2029.
- Searsport transitions exclusively to FOWT deployment in 2030.

Sheet 2: Searsport Floating OWT (FOWT) deployments with EPA Award

- Searsport begins in 2030 with the deployment of fifteen 15 MW FOWTs.
- Deployment capacity increases by one OWT per year up to 24 FOWTs in 2039.
- In 2040, OWT size jumps from 15 MW to 20 MW and twenty-four 20 MW FOWTs are deployed from Searsport.
- FOWT deployment maxes out at Searsport in 2046 at thirty 20 MW OWTs.
- Searsport deploys thirty 20 MW FOWTs each year between 2046 and 2049.
- This deployment scenario reaches a total of 8505 MW by the end of 2049 (Table 2).

Sheet 3: Salem FOWT deployments with EPA Award

- Salem begins to deploy floating offshore wind in 2035 with ten 15 MW FOWTs.
- Deployment capacity increases by one FOWT per year up to 14 OWTs in 2039.
- In 2040, FOWT size jumps from 15 MW to 20 MW and fourteen 20 MW FOWTs are deployed from Salem.
- FOWT deployment increases by one 20 MW FOWT per year up to 20 FOWTs in 2046.
- Twenty 20 MW FOWTs are deployed annually from 2046 to 2049.
- This deployment scenario reaches a total of 4480 MW by the end of 2049.

Sheet 4: Searsport FOWT deployments without EPA Award

- Searsport begins in 2035 with the deployment of fifteen 15 MW FOWTs.
- Deployment capacity increases by one FOWT per year up to 19 OWTs in 2039.
- In 2040, FOWT size jumps from 15 MW to 20 MW and nineteen 20 MW FOWTs are deployed from Searsport.
- FOWT deployment increases by one 20 MW FOWT per year up to 28 FOWTs in 2049.
- This deployment scenario reaches a total of 5975 MW by the end of 2049.

Sheet 5: Salem FOWT deployments without EPA Award

- Salem begins to deploy floating offshore wind in 2040 with ten 20 MW FOWTs.
- Deployment capacity increases by one FOWT per year up to 19 OWTs in 2049.
- This deployment scenario reaches a total of 2900 MW by the end of 2049.

Sheet 6: Synthesis of Searsport + Salem OWT and FOWT deployments in MW

- Searsport assists OWT deployment with 150 MW in 2028 and 195 MW in 2029 for a cumulative total of 345 MW by 2029.
- Total cumulative OWT and FOWT deployments reach 13330 MW by end of 2049 with the EPA-CPRG Award.

- Total cumulative OWT and FOWT deployments reach 8875 MW by end of 2049 without the EPA CPRG Award.
- Annual impact of EPA-CPRG Award = (**Total+EPA**) – (**Total-EPA**). For example, in year 2049, the impact of the EPA-CPRG Award = 13330 MW – 8875 MW = 4455 MW.

Sheet 6 Chart: Floating Offshore Wind Growth

This chart shows the estimated FOSW deployment curves with and without the EPA CPRG Award. This total area between these two curves represents the opportunity space for total emissions reductions modeled for this proposal.

Sheet 7: Emissions Reduction Calculations

- Calculate the annual difference of OWT and FOWT deployments in MW by subtracting the **Total-EPA** from the **Total+EPA** columns in Sheet 6. This results in Column B in this Sheet 7.
- Estimate the annual fossil fuel energy usage offset in gigawatt-hours (GWh) based on this difference and assuming a capacity factor of 50%, which is reasonable for the extremely rich offshore wind resource in the Gulf of Maine. For example, in 2049: (4455 MW)(0.50)(8706 h/y)/(1000 MW/GW) = 19,513 GWh/y. This means that 19,513 GWh/y of electricity in 2049 are generated by offshore wind and not by fossil fuel fired power plants, resulting in a reduction of 19,513 GWh/y of emitting energy in 2049 **(see Cell C27)**.
- Determine emissions reductions based on the GWh and reduction coefficient estimated for a given year. See Emissions Coefficients in Sheet 8.
- Total CO_2e emissions reductions between 2025-2050 = 50,870,067 MMT **(see Cell C28)**.

Sheet 8: Emissions Coefficients – Please see below. Sheet 8 is described out of order because its coefficients were used for all of the relevant scenarios.

Sheets 9 and 10

Sheets 9 and 10 estimate emissions reductions from Salem Port Electrification and reduced service vessel traffic from the Canadian Maritimes.

Sheet 9: Salem Port Electrification

- Tool: EPA Shore Power Emissions Calculator
- Vessel Types and Usage
    - Barge
    - Heavy Lift Vessel
    - Tug Boat
- With EPA-CPRG, Salem becomes fully electrified by 2040.
- Without EPA-CPRG, Salem does not electrify at all.
- Difference is calculated in Table below assuming without the EPA-CPRG, the electrification ramp from 2025 to full electrification in 2040 is assumed to be linear.

Table 3. Vessel type and shore power specifications for Salem, considering the NEWE eGRID Subregion.

Emissions Calculator: High Capacity Shore Power Connection - User Entry Calculator						
eGRID Subregion ?	**Vessel Type**	**Fuel / Engine Tier**	**Number of Annual Vessel Calls**	**Average Hotel Hours per Vessel Call**	**Auxiliary Engine hotelling Load (kW)**	**Annual Energy Consumption (kWh)**
Dropdown	Dropdown	Dropdown	Number Input	Number Input	Built in	Output
NEWE	Barge	MGO (0.10% S) - Tier II	42	18	375	283,500
NEWE	Heavy Lift Vessel	MGO (0.10% S) - Tier II	30	48	4000	5,760,000
NEWE	Tug Boat	MGO (0.10% S) - Tier II	75	18	170	229,500

Table 4. Estimated Annual Vessel Power and Shore Power Emissions in metric tons.

Emissions Calculator:		**Annual Vessel Power Emissions (MT)**					**Annual Shore Power EGU Emissions (MT)**					**Annual Difference (MT)**				
eGRID Subregion ?	**Vessel Type**	**NOx**	**SO_2**	**$PM_{2.5}$**	**CO_2**	**CO_2eq**	**NOx**	**SO_2**	**$PM_{2.5}$**	**CO_2**	**CO_2eq**	**NOx**	**SO_2**	**$PM_{2.5}$**	**CO_2**	**CO_2eq**
Dropdown	Dropdown	Output	Output	Output	Output	Output	Output	Output	Output	Output	Output	Output	Output	Output	Output	Output
NEWE	Barge	3.0	0.120	0.047	197	200	0.049	0.011	0.006	72	72	-2.928	-0.109	-0.041	-125	-128
NEWE	Heavy Lift Vessel	60.5	2.442	0.956	4,009	4,061	1.001	0.232	0.128	1,457	1,470	-59.479	-2.210	-0.828	-2,552	-2,591
NEWE	Tug Boat	2.4	0.097	0.038	160	162	0.040	0.009	0.005	58	59	-2.370	-0.088	-0.033	-102	-103
		65.867	**2.659**	**1.041**	**4,366**	**4,423**	**1.090**	**0.252**	**0.139**	**1,587**	**1,601**	**-64.777**	**-2.407**	**-0.902**	**-2,779**	**-2,822**

Sheet 10: Reduced Vessel Traffic from the Canadian Maritimes

- Assume that Searsport is approximately 100 nautical miles (nm) from the Gulf of Maine OSW energy areas. Assume that Halifax is approximately 250 nm from the Gulf of Maine OSW energy areas.
- Calculate reduced emissions based on a 150 nm x 2 = 300 nm round-trip differential.
- Refer to Table 3 in: https://ore.catapult.org.uk/wp-content/uploads/2021/02/VesselEmissionsOM_Final.pdf
- Focus on Crew Transfer Vessels (CTV) and Service Operations Vessels (SOV)

Table 5. Additional distance, duration, and emissions estimated per trip for service from Halifax instead of Searsport.

	CTV	SOV	
distance	300	300	nm
speed	23	12	knots
duration	13	25	hrs
CO2/hr	984.7	2737.8	kg/hr
CO2/trip	12.8	68.4	mt
N2O	14	36.9	kg/hr
N2O/trip	0.183	0.923	mt

c. Emission Reduction Estimate Assumptions:

Sheet 8: Emissions Coefficients

Emissions coefficient baselines are taken from EPA-eGRID 2022 for the NEWE Subregion "Total output emission rates" which are conservative compared to "Non-baseload output emission rates" shown in Table 1. The 2050 Emissions coefficient for this analysis is estimated by assuming that floating OSW is the only technology that moves forward in NEWE of all the technologies listed in Table 2. This results in a 21.1% reduction in 2022 emissions numbers, which means that CO_2e goes from 540.5 lbs/MWh in

2022 to 426.7 lbs/MWh in 2049 resulting in a differential of 113.8 lbs/MWh between these two years. Emissions coefficients are held constant from 2022 to 2027 to reflect the assumption that no new generation is added between these years. Emissions coefficients begin to reduce in 2028 with the addition of new OSW capacity as a result of EPA-CPRG funding.

d. Reference Case Scenario:

The reference case scenario is included in the build-out of the FOSW deployments in Sheets 1-6 of the attached Workbook and shown Figure 1.

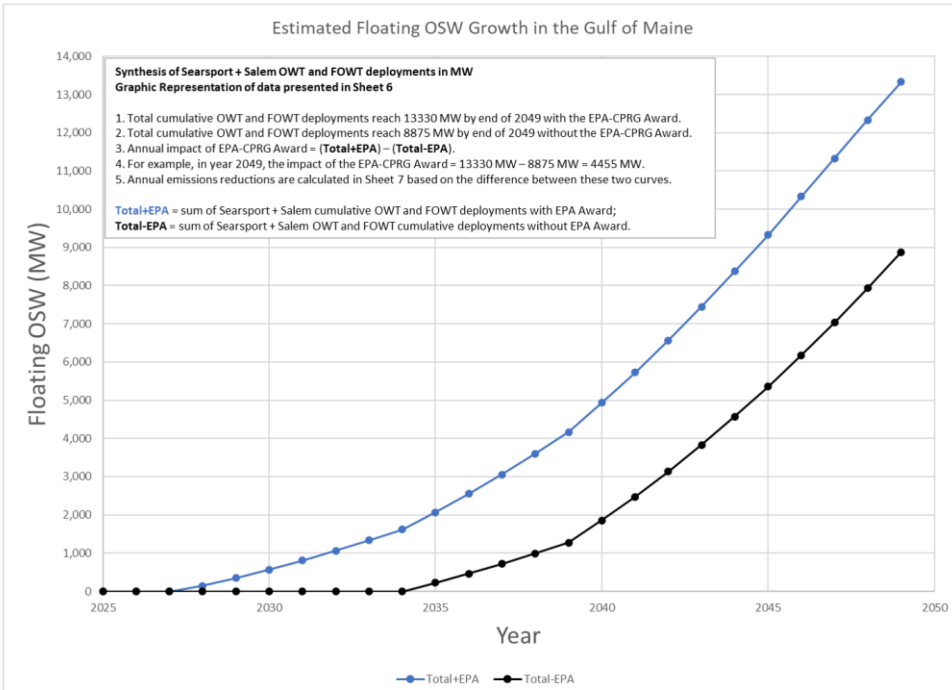

Figure 1. Estimated Floating OSW Growth in the Gulf of Maine. The blue "Total+EPA" curve shows the case with CPRG funding and the black "Total-EPA" curve shows the case without CPRG funding. The area between these two curves is the total FOSW deployment differential on which cumulative annual emissions reductions are based for this proposal.

e. GHG and Co-pollutant Emissions Reduced:

Implementation of this measure is anticipated to reduce annual mtCO_2 e emissions as shown in Table 1, with 531,560 cumulative mtCO_2e for the period between 2025 – 2030, and 50,902,519 cumulative mtCO_2e for the period between 2025 – 2050.

Table 6. Summary of Emissions Reductions as shown in Sheet 11 of the Workbook.

Case	CO_2e	SO_2	NOx	OS-Nox	N_2O	PM2.5
2025-2050 Total	50,933,088	11,524	30,216	26,635	196	16
2025-2030 Total	528,218	120	346	275	25	1
OSW	524,364	118	300	275		
Salem Port Elect.	1,985	2	46			1
Canadian Mar.	1,870				25	

2030-2050 Total	50,404,869	11,404	29,870	26,360	170	15
FOSW	50,345,703	11,364	28,782	26,360		
Salem Port Elect.	46,648	40	1,087			15
Canadian Mar.	12,518				170	