Draft Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft

Cost Analysis Inputs and Assumptions for Standardized Regulatory Impact Assessment

This document was prepared by California Air Resources Board (CARB) staff to document the inputs used in the development of preliminary cost estimates for the Draft Proposed Amendments to the Airborne Toxic Control Measure for Commercial Harbor Craft (hereinafter Proposed Amendments). CARB staff is developing the cost estimates for the Standardized Regulatory Impact Assessment (SRIA), which is required by Senate Bill (SB) 617 for proposed regulations that have an economic impact exceeding $50 million. **This document, and the accompanying cost calculations, are preliminary discussion drafts and are still under development. CARB staff is releasing these documents in advance of the SRIA and Initial Statement of Reasons (ISOR) for the Proposed Amendments solely to request stakeholder input regarding these inputs and the preliminary cost estimates**. To date, CARB staff has incorporated information received from various sources including many industry stakeholders, and continues to request additional data to further refine the cost analysis.

Please submit comments or cost information to both Wei Liu and Ashley Arax by October 30, 2020 to be considered for inclusion in the SRIA. Stakeholders can also continue to provide informal comments throughout the regulatory process, and formal comments during the 45-day public comment period that will occur prior to the Board's consideration of the Proposed Amendments.

Contents

Table I: Scope and Timing of Analysis

Years of Cost Analysis	2023 through 2037
Proposed Timeline of Major Compliance Requirements for Existing and Proposed Regulation	**Table I-A : Implementation Timeline for Existing and Proposed Amendments**

Existing Regulation (Implementation Dates)			**Proposed Amendments (Implementation Dates)***									
≤ 2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
IN-USE VESSEL REQUIREMENTS*												
Tier 2 or 3 (Tugs, Ferries, Excursion, Crew & Supply, Barge, Dredge)			**Any Tier 0 and 1 to Tier 3 or 4****									
			≤ MY 1993	MY 1994-2001	MY 2002-2006							
				Tier 2, 3, 4 to Tier 3+DPF & Tier 4+DPF (Ferry, Pilot, All Tugs)								
				MY 2007-2009	MY 2010-2012	MY 2013-2015	MY 2016-2019	MY 2020-2021	MY 2022+			
						Tier 2, 3, 4 to Tier 3+DPF & Tier 4+DPF (Research, Commercial Passenger Fishing, Excursion)						
						MY 2007-2010	MY 2011-2012	MY 2013-2014	MY 2015-2017	MY 2017+		
								Tier 2, 3, 4 to Tier 3+DPF & Tier 4+DPF (Dredges, Barges, Crew & Supply, Workboats)				
								MY 2007-2009	MY 2010-2013	MY 2014-2017	MY 2017+	
										Pre-Tier 1 and Tier 1 to Tier 2 and above (Commercial Fishing)		
										≤ MY 1987	MY 1988-1997	MY 1998+

<table>
<tr><td></td><td>
<table>
<tr><td colspan="3">NEW VESSEL REQUIREMENTS</td></tr>
<tr><td>Tier 2, 3, or 4 (All Vessels)
Tier 3 + BACT (New Ferries Carrying 75 or More Passengers)</td><td></td><td>New Excursion: Zero-Emission Capable (e.g. Plug-in Hybrid, 30% or more of power must be derived from zero-emission tailpipe source)</td></tr>
<tr><td colspan="3">REQUIREMENTS FOR ALL NEW AND IN-USE HARBOR CRAFT OPERATING IN CALIFORNIA</td></tr>
<tr><td></td><td></td><td>All Short-Run Ferries: Zero-Emission</td></tr>
</table>
*Tier 3 + DPF requirements apply to engines <=600 kW, and Tier 4 + DPF requirements apply to engines >600 kW.
**Generally Workboats, Research, Pilot, Tank Barges, and Commercial Passenger Fishing

For the purpose of our cost analysis release at this time, Tier 3 + diesel particulate filter (DPF) requirements apply to engines <=600 kilowatts (kW), and Tier 4 + DPF requirements apply to engines >600 kW. Currently, CARB staff is aware of one manufacturer with Tier 4 marine engines certified below 600 kW; therefore, CARB staff expects the majority of engines rated below 600 kW to repower to Tier 3 marine standards, and structured the cost analysis to reflect this. However, the current regulatory proposal remains that Tier 4 + DPF is required for engines of any power rating where U.S. EPA has certified engines to Tier 4 standards.

Table I-B: Regulation Timeline: Mandates for Zero-Emission and Advanced Technologies
<table>
<tr><th>Marine Technology Type</th><th>Vessel Category Requirement</th><th>Mandate Phase In Date</th></tr>
<tr><td>Zero-Emission Capable Hybrid</td><td>New Excursion Vessels</td><td>January 1, 2025</td></tr>
<tr><td>Zero-Emission</td><td>New and In-Use Short Run (<3 nautical miles [nm]) Ferries</td><td>January 1, 2026</td></tr>
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<tr><td>CARB staff Assumptions Regarding Timing of Costs</td><td>Major Costs

Capital, Labor, and Installation Costs (including Redundant Labor and Installation Costs) would begin on the vessel compliance year as outlined in Tables I-A and I-B and are amortized according to the Engine Capital Recovery Factor Table I-I.

Non-amortized scenarios assume that the Capital, Labor and Installation Costs would be incurred during the vessel compliance year as outlined in Tables I-A and I-B.

Operational Costs would begin on the vessel compliance year as outlined in Tables I-A and I-B.
Loss of Use Costs result from downtime during the retrofit and/or repower process, and as such, apply to repower and retrofit scenarios only. These costs would begin on the vessel compliance year as outlined in Tables I-A and I-B and are amortized according to the Engine Capital Recovery Factor Table I-I.
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</table>

	○ Non-amortized scenarios assume that Loss of Use Costs would be incurred during the vessel compliance year as outlined in Tables I-A and I-B. • Vessel Replacement Costs would begin on the vessel compliance year as outlined in Tables I-A and I-B. and are amortized according to the Vessel Capital Recovery Factor Table I-H. ○ Non-amortized scenarios assume that Vessel Replacement Costs would be incurred during the vessel compliance year as outlined in Tables I-A and I-B. • Vessel Residual/Resale Value Before Replacement applies to vessel replacements only. These values would begin on the vessel compliance year as outlined in Tables I-A and I-B and are amortized according to the Vessel Capital Recovery Factor Table I-H. ○ Non-amortized scenarios assume that Residual/Resale Value Before Replacement values would be apply during the vessel compliance year as outlined in Tables I-A and I-B. • Low Use Exemption Costs would begin on the vessel compliance year as outlined in Tables I-A and I-B. Administrative Costs • Recordkeeping and Reporting and Facility Report Costs would occur annually beginning in 2023. • Vessel Labeling Cost ($ per vessel) would occur every five years beginning in 2023. • Opacity Testing Cost ($ per vessel) would occur bi-annually starting in 2023. • Personnel Years (PY) Costs for Implementation and Enforcement of Regulation would occur annually starting in 2023. • Compliance Extension Costs ○ Financial Feasibility Report Cost: CARB staff assume the Financial Feasibility Report Cost would occur from 2023 to 2034, based on the regulation's phase-in compliance dates and the available three year extension periods. ○ Naval Architect Report Cost: CARB staff assume the Naval Architect Report Cost would occur from 2023 to 2034, based on the regulation's phase-in compliance dates and the available three year extension periods. Infrastructure Costs • Dock Power Infrastructure Costs would occur starting in 2023 and are amortized according to a capital recovery factor of 0.08, which was calculated using a 5 percent interest rate and a 20 year infrastructure useful life. CARB staff is exploring the option of using a lower interest rate in future analyses for public entities (e.g., ports) based on their lower cost of debt compared to industry. ○ Non-amortized scenario assumes that the Dock Power Infrastructure Costs would occur from 2023-2024, and would be evenly distributed over the two year construction period.

	• Short Run Ferry and Excursion Vessel Charging Infrastructure Costs would occur two years before the Excursion Vessel initial compliance date and are amortized according to a capital recovery factor of 0.08, which was calculated using a 5 percent interest rate and a 20 year infrastructure useful life. CARB staff is exploring the option of using a lower interest rate in future analyses for public entities (e.g., ports) based on their lower cost of debt compared to industry. ○ Non-amortized scenario assumes that the Charging Infrastructure Costs would occur starting in 2023 (two years before the Excursion Vessel initial compliance date) to 2025, and would be evenly distributed over the three year construction period.

CARB Staff Assumptions Regarding Compliance Scenarios

Table I-C: Compliance Scenario Assumptions for Tier 0 and Tier 1 to Tier 3 Repowers (Engines <=600kW)

Vessel Category	% Vessel Repowers by Initial Compliance Date
Ferry, Catamaran	100%
Ferry, Monohull	100%
Ferry, Short Run	100%
Pilot Boat	100%
Push/Tow Tug	100%
Escort/Ship Assist Tug	100%
ATB Tug	100%
Research Vessel	100%
Commercial Passenger Fishing	100%
Excursion	100%
Dredge	100%
ATB Barge	100%
Bunker Barge	100%
Other Barge	100%
Crew Supply	100%
Workboat	100%
Commercial Fishing	100%

CARB staff assume 100 percent of vessels with Tier 0 and Tier 1 engines <=600kW would be able to repower by the initial compliance date.

CARB Staff Assumptions Regarding Compliance Scenarios (cont'd)

Table I-D: Compliance Scenario Assumptions for Tier 0 and Tier 1 to Tier 4 Repowers (Engines >600kW)

Vessel Category	% Vessel Retrofits or Repowers by Initial Compliance Date	% Vessel Replacements by Initial Compliance Date	% Vessels Granted 1st Extension	% Vessel Retrofits or Repowers after 1st Extension	% Vessel Replacements after 1st Extension	% Vessel Repowers or Retrofits after 2nd Extension	% Vessel Replacements after 2nd Extension
Ferry, Catamaran	75%	5%	20%	5%	5%	5%	5%
Ferry, Monohull	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Ferry, Short Run	100%	0%	0%	0%	0%	0%	0%
Pilot Boat	75%	5%	20%	5%	5%	5%	5%
Push/Tow Tug	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Escort/Ship Assist Tug	95%	5%	0%	0%	0%	0%	0%
ATB Tug	95%	5%	0%	0%	0%	0%	0%
Research Vessel	75%	5%	20%	5%	5%	5%	5%
Commercial Passenger Fishing	50%	5%	45%	11.25%	11.25%	11.25%	11.25%
Excursion	95%	5%	0%	0%	0%	0%	0%
Dredge	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
ATB Barge	95%	5%	0%	0%	0%	0%	0%
Bunker Barge	95%	5%	0%	0%	0%	0%	0%
Other Barge	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Crew Supply	75%	5%	20%	5%	5%	5%	5%
Workboat	75%	5%	20%	5%	5%	5%	5%

The compliance scenarios listed in the table are based on the following CARB staff assumptions:

- There are various reasons, including technical feasibility issues, which would prevent all vessels from being retrofit or repowered by their initial compliance date. Rather than apply for an extension, CARB staff assume

CARB Staff Assumptions Regarding Compliance Scenarios (cont'd)	that 5 percent of vessels (except for Short Run Ferries) would be replaced by their initial compliance date due to the owners' ability to incur the cost of a vessel replacement.
	• For Short Run Ferries, CARB staff assume 100 percent would be retrofit/repowered instead of replaced due to the large cost difference between a vessel replacement vs. retrofit/repower. Additionally, CARB staff have identified Short Run ferries being repowered with zero-emission powertrains in other regions of the United States. CARB staff assume no compliance extension requests for this category due to a later regulatory phase-in date of 2026.
	• The percentage of vessels that would repower or retrofit by the first compliance date is based on vessel repower and retrofit feasibility fitment factors reported in the *"Evaluation of the Feasibility and Costs of Installing Tier 4 Engines and Retrofit Exhaust Aftertreatment on In-Use Commercial Harbor Craft"* conducted by California State University Maritime Academy, September 2019 (Cal Maritime Study):
	  ○ Feasible fitment for most options = 95 percent;
	  ○ Moderate reconfiguration for most options = 90 percent;
	  ○ Substantial reconfiguration = 75 percent;
	  ○ No fitment = 50 percent.
	• The percentage of vessels that would receive compliance extensions is equal to: One minus the sum of the feasibility fitment factor and the percentage of vessels replaced by the initial compliance date.
	• At the end of the first compliance extension period, the vessel owner would have three compliance pathways, and CARB staff assume the following percentages for each pathway: 1) file for a second extension (50 percent); 2) repower or retrofit the vessel (25 percent), or; 3) replace the vessel (25 percent).
	• At the end of the second compliance extension period, the vessel owner would have two compliance pathways, and CARB staff assume the following percentages for each pathway: 1) repower or retrofit the vessel (50 percent), or; 2) replace the vessel (50 percent). Although Workboats would not have compliance extension limitations, the cost workbook treats this vessel category the same as other vessel categories for modeling simplicity.

CARB Staff Assumptions Regarding Compliance Scenarios (cont'd)

Table I-E: Compliance Scenario Assumptions for Tier 2 and Tier 3 to Tier 3 + DPF (Engines <=600kW) and Tier 2, Tier 3, and Tier 4 to Tier 4+DPF (Engines >600kW)

Vessel Category	% Vessel Retrofits or Repowers by Initial Compliance Date	% Vessel Replacements by Initial Compliance Date	% Vessels Granted 1st Extension	% Vessel Repowers or Retrofits after 1st Extension Period	% Vessel Replacements after 1st Extension Period	% Vessel Repowers or Retrofits after 2nd Extension	% Vessel Replacements after 2nd Extension
Ferry, Catamaran	50%	5%	45%	11.25%	11.25%	11.25%	11.25%
Ferry, Monohull	80%	5%	15%	3.75%	3.75%	3.75%	3.75%
Ferry, Short Run	100%	0%	0%	0%	0%	0%	0%
Pilot Boat	50%	5%	45%	12.5%	12.5%	12.5%	12.5%
Push/Tow Tug	80%	5%	15%	3.75%	3.75%	3.75%	3.75%
Escort/Ship Assist Tug	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
ATB Tug	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Research Vessel	50%	5%	45%	11.25%	11.25%	11.25%	11.25%
Commercial Passenger Fishing	30%	5%	65%	16.25%	16.25%	16.25%	16.25%
Excursion	90%	5%	5%	1.25%	1.25%	1.25%	1.25%
Dredge	80%	5%	15%	3.75%	3.75%	3.75%	3.75%
ATB Barge	90%	5%	5%	0%	0%	0%	0%
Bunker Barge	90%	5%	5%	0%	0%	0%	0%
Other Barge	80%	5%	15%	3.75%	3.75%	3.75%	3.75%
Crew Supply	50%	5%	45%	12.5%	12.5%	12.5%	12.5%
Workboat	50%	5%	45%	11.25%	11.25%	11.25%	11.25%

The compliance scenarios listed in the table are based on the following CARB staff assumptions:

- There are various reasons, including technical feasibility issues, which would prevent all vessels from being retrofit or repowered by their initial compliance date. Rather than apply for an extension, CARB staff assume

CARB Staff Assumptions Regarding Compliance Scenarios (cont'd)	that 5 percent of vessels (except for Short Run Ferries) would be replaced by their initial compliance date due to the owners' ability to incur the cost of a vessel replacement.
	• For Short Run Ferries, CARB staff assume 100 percent would be retrofit/repowered instead of replaced due to the large cost difference between a vessel replacement vs. retrofit/repower. Additionally, CARB staff have identified Short Run ferries being repowered with zero-emission powertrains in other regions of the United States. CARB staff assume no compliance extension requests for this category due to a later regulatory phase-in date of 2026.
	• The percentage of vessels that would repower or retrofit by the first compliance date is based on vessel repower and retrofit feasibility fitment factors reported in the Cal Maritime Study:
	  ○ Feasible fitment for most options = 90 percent;
	  ○ Moderate reconfiguration for most options = 80 percent;
	  ○ Substantial reconfiguration = 50 percent;
	  ○ No fitment = 30 percent.
	• The percentage of vessels that would receive compliance extensions is equal to: One minus the sum of the feasibility fitment factor and the percentage of vessels replaced by the initial compliance date.
	• At the end of the <u>first</u> compliance extension period, the vessel owner would have three compliance pathways, and CARB staff assume the following percentages for each pathway: 1) file for a second extension (50 percent); 2) repower or retrofit the vessel (25 percent), or; 3) replace the vessel (25 percent).
	• At the end of the <u>second compliance</u> extension period, the vessel owner would have two compliance pathways, and CARB staff assume the following percentages for each pathway: 1) repower or retrofit the vessel (50 percent), or; 2) replace the vessel (50 percent). Although Workboats would not have compliance extension limitations, the cost workbook treats this vessel category the same as other vessel categories for modeling simplicity.

CARB Staff Assumptions Regarding Vessels Qualifying for Low Use Exemption

Table I-F: Low Use Percentages by CHC Category

Vessel Category	Low Use	Basis
Ferry, Catamaran	7%	The percentage is based on data from CARB's CHC Reporting Database.
Ferry, Monohull	7%	The percentage is based on data from CARB's CHC Reporting Database.
Ferry, Short Run	7%	The percentage is based on data from CARB's CHC Reporting Database.
Pilot Boat	3%	The percentage is based on data from CARB's CHC Reporting Database.
Push/Tow Tug	8%	The percentage is based on data from CARB's CHC Reporting Database.
Escort/Ship Assist Tug	10%	The percentage is based on data from CARB's CHC Reporting Database.
ATB Tug	0%	The percentage is based on data from CARB's CHC Reporting Database.
Research Vessel	16%	The percentage is based on data from CARB's CHC Reporting Database.
Commercial Passenger Fishing	4%	The percentage is based on data from CARB's CHC Reporting Database.
Excursion	25%	The percentage is based on data from CARB's CHC Reporting Database.
Dredge	1%	The percentage is based on data from CARB's CHC Reporting Database.
ATB Barge	0%	The percentage is based on data from CARB's CHC Reporting Database.
Bunker Barge	13%	The percentage is based on data from CARB's CHC Reporting Database.
Other Barge	13%	The percentage is based on data from CARB's CHC Reporting Database.
Crew Supply	8%	The percentage is based on data from CARB's CHC Reporting Database.
Workboat	21%	The percentage is based on data from CARB's CHC Reporting Database.
Commercial Fishing	5%	The percentage is based on data from CARB's CHC Reporting Database.

Constant Values used in Cost Calculations

- **DPF Fuel Penalty:** 4.15 percent was derived by taking the average of six different DPF fuel penalty percentages from the CARB DPF verification database. In order to select the six values, CARB staff analyzed seven verification applications to CARB (confidential data source that requested non-attribution) for DPF products used in TRU, Stationary, and Marine applications with various regeneration strategies, and determined that one application for a passive DPF system was not applicable due to its passive regeneration strategy.
- **Diesel Exhaust Fluid (DEF) Consumption Rate:** 3.75 percent was derived by taking the average of the values from the following sources:

- Caterpillar, which reported a DEF consumption rate of 3-8 percent (the average value of 5.5 percent was used in the calculation) in the following document: https://www.cat.com/en_US/by-industry/marine/tier-four/your-questions-answered/def-faqs.html, accessed July 2020.
- Cummins, which reported a DEF consumption rate of 2 percent in the following document: https://www.cumminsfiltration.com/sites/default/files/MB10033.pdf, accessed April 2020.

- **DPF Cleaning Cost ($/horsepower [hp]):** $1.00 was derived by dividing a CARB staff estimate of $400 per year in maintenance costs from the Truck and Bus Regulation in 2008 (see page J-17 in https://ww3.arb.ca.gov/regact/2008/truckbus08/appj.pdf) by an average truck hp of 400 (CARB staff assumption).
- **DEF Cost ($/gallon):** $1.75 is taken from the Cal Maritime Study.
- **DPF Drag Penalty ($/gallon):** $0 is based on CARB staff's assumption that there would be no functional increase in drag, given that other measures would be taken to maintain existing vessel weight, like passenger count reductions, and that the weight of the fuel in the vessel is significantly larger than the heavier engines and after treatment devices.
- **Diesel Fuel Cost ($/gallon):** $3.90 is based on a 2019 California Diesel (On-Highway) Cost from US. Energy Information Administration, https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sca_a.htm, accessed July 2020.
- **Costs Savings (Diesel to Electricity) ($/hp-hour [hp-hr]):** $-0.07 was derived by taking a brake-specific fuel consumption for engines over 99 hp of 0.367lbs/hp-hr, which is equivalent to 34.7 percent efficiency. Assuming diesel cost is $3.90/gallon, the cost for diesel per kW-hr is at $0.28/kWh equivalent ($3.90 per gallon/(1 gallon x 3.785L/gal x 38.6 MJ/L x 1kWh/3.6 MJ x 34.7 percent efficiency)). The 2019 cost of electricity is $0.18 per kWh (California Energy Commission Mid Case Revised Demand Forecast, updated February 21, 2018), so the cost savings for using electricity instead of diesel is at $0.10 per kW-hr, or $0.07 per hp-hr.

Vessel Growth Factors

Table I-G-i: Vessel Growth Factors by CHC Category

Vessel Category	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Ferry	0.0%	1.5%	1.5%	1.6%	1.6%	1.6%	1.6%	1.6%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
Pilot Boat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Push/Tow Tug	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Escort/Ship Assist Tug	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ATB Tug	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Research Vessel	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Commercial Passenger Fishing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Excursion	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Dredge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ATB Barge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bunker Barge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other Barge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Crew Supply	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Workboat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Commercial Fishing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

CARB staff analyzed reported inventories of CHC from the Ports of Los Angeles and Long Beach, and reporting data to CARB from the past decade to generate estimated vessel growth factors. Based on relatively flat historical growth trends, CARB staff assumed zero population growth for all vessel categories except Ferries. CARB staff based Ferry growth assumptions on the San Francisco Bay Area Water Emergency Transportation Authority (WETA) *2016 Strategic Plan*, which provides a growth projection that CARB staff applied Statewide. The Ferry growth percentages apply to Catamaran, Monohull, and Short Run Ferry categories. Regarding Ferry growth factor percentages, CARB staff is evaluating impacts on ridership levels due to the COVID-19 pandemic and projected ridership recovery.

The vessel growth factor percentage is applied to each cost input within a vessel category to account for changes in vessel population.

Table I-G-ii: Compounded Vessel Growth Factors

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Compound Growth Factor	0.0%	0.059 %	0.061 %	0.062 %	0.064 %	0.066 %	0.068 %	0.07 %	0.072 %	0.074 %	0.076 %	0.078 %	0.08 %	0.08 %	0.08 %

The compounded vessel growth factor percentage is for all CHC vessel categories combined, and applies to Dock Power Retrofit Cost inputs.

Vessel Capital Recovery Factor

Table I-H: Vessel Capital Recovery Factors by CHC Category

Vessel Category	Interest Rate	Useful Life (Years)	Capital Recovery Factor
Ferry (Catamaran)	5%	42	0.0574
Ferry (Monohull)	5%	42	0.0574
Ferry (Short Run)	5%	42	0.0574
Pilot Boat	5%	42	0.0574
Push/Tow Tug	5%	54	0.0539
Escort/Ship Assist Tug	5%	54	0.0539
ATB Tug	5%	54	0.0539
Research Vessel	5%	47	0.0556
Commercial Passenger Fishing	5%	53	0.0541
Excursion	5%	54	0.0539
Dredge	5%	42	0.0574
ATB Barge	5%	42	0.0574
Bunker Barge	5%	42	0.0574
Other Barge	5%	42	0.0574
Crew Supply	5%	53	0.0541
Workboat	5%	47	0.0556

The Vessel Capital Recovery Factor (CRF) is calculated using the following equation:

$$CRF = i * \frac{(1+i)^n}{(1+i)^n - 1}$$

Where, CRF is Capital Recovery Factor, i is the interest rate, and n is the useful financial period. CARB staff assume the useful financial period is equal to the vessel's useful life, which is the age when 50 percent of the vessels retire in the fleet. The useful life period for each vessel category is determined using survival curves developed from CARB reporting data. See Table 1: "Engine and Vessel Population" for more information.

The Vessel Capital Recovery Factor is applied to the Unit Vessel Replacement Cost in the Vessel Replacement scenario.

Engine Capital Recovery Factor

Table I-I: Engine Capital Recovery Factors by CHC Category

Vessel Category	Interest Rate	Useful Life (Years)	Capital Recovery Factor
Ferry (Catamaran)	5%	15	0.0963
Ferry (Monohull)	5%	15	0.0963
Ferry (Short Run)	5%	15	0.0963
Pilot Boat	5%	15	0.0963
Push/Tow Tug	5%	14	0.1010
Escort/Ship Assist Tug	5%	14	0.1010
ATB Tug	5%	14	0.1010
Research Vessel	5%	22	0.0760
Commercial Passenger Fishing	5%	16	0.0923
Excursion	5%	15	0.0963
Dredge	5%	15	0.0963
ATB Barge	5%	14	0.1010
Bunker Barge	5%	25	0.0710
Other Barge	5%	14	0.1010
Crew Supply	5%	13	0.1065
Workboat	5%	22	0.0760
Commercial Fishing	5%	31	0.0641

	The Engine Capital Recovery Factor is calculated using the following equation: $CRF = i * \frac{(1+i)^n}{(1+i)^n - 1}$ Where, CRF is Capital Recovery Factor, i is the interest rate, and n is the useful financial period. CARB staff assume the useful financial period is equal to the engine's useful life, which is the age when 50 percent of the engines are retired in the fleet. Main engines are used to represent all vessel categories, except for Articulated Tug Barge (ATB) and Other Barge, where the useful life for auxiliary engines is used. The Engine Capital Recovery Factor is applied to the Total Engine Capital, Labor and Installation Cost and the Loss of Use Cost in the Retrofit and Repower scenarios.
Engine and Vessel Population	The cost workbook multiplies $/hp cost values for each compliance pathway by a total hp amount per year, starting in 2023. CARB staff used the CHC engine inventory to determine the total hp values, which are determined based on the engine type (main or auxiliary), engine model year, average engine hp, and natural turnover populations. This total hp is broken down by vessel category. • For example, to calculate the total number of "Push/Tow Tug" hp that would be subject to the Repower Tier 4 compliance pathway in 2023, CARB staff used the CHC engine inventory to identify all Push/Tow Tug Tier 0 and Tier 1 main and auxiliary engines greater than 800 hp (equivalent to 600 kW) with model years equal to or older than 1993 (based on the phase-in compliance date). A vessel survival percentage based on the engine's age was applied to each engine's average hp, and the values were added together to get the total hp per year. The following provides information about the methodology and CARB staff assumptions for the CHC engine inventory and vessel population: • Vessel population: CHCs operating in Regulated California Waters are required to report to CARB per 17 California Code of Regulations (CCR) § 93118.5, the Airborne Toxic Control Measure for Commercial Harbor Craft. CARB's CHC inventory is largely built around this reporting data. In order to check the total population, CARB cross referenced reporting with the U.S. Coast Guard (USCG) Merchant Vessel Database for vessels with a hailing port in California. The CHC vessel population from CARB reporting as of February 2019 (1,908 vessels) is only about 50 percent of that reported by U.S. Coast Guard (USCG) (3,692 vessels), suggesting that half of the operating CHCs are not reported to CARB. To account for the

larger population of CHC in the USCG data, CARB staff scaled up reporting data to match the total population in the USCG registry. This maintains the specificity of the reporting data information (e.g. number of engines, horsepower, activity) while providing a more comprehensive population total than the CARB reporting data alone.

- For CHC in port of Oakland and Richmond, all ferries, ATB tugs, and pilot boats, the reported population is unchanged.
- For vessel types that could be matched between the two sources (barges, commercial fishing, tugs, and Research Vessels), the reported population is scaled up by vessel type.
- For all other vessels, reported population is scaled up by location.
  - For the top seven ports with vessel population >100, the vessel population scaled at port level.
    - San Francisco, Los Angeles/Long Beach, San Diego, Eureka, Fort Bragg, Newport Beach, Santa Barbara
  - For all other ports, the vessel population is scaled to match the remaining USCG reports.
- CARB staff is working to evaluate a number of potential refinements to the engine and vessel population. These refinements would be reflected in the inventory at a later date, and are not reflected in the cost calculations:
  - Refine the Push/Tow Tug and Escort/Ship Assist Tug population based on information provided by industry stakeholders.
  - Adjust the vessel population downward about 10 percent from baseline levels based on stakeholder information that vessels without a valid Certificate of Documentation are not in operation.
  - Rename “Charter Fishing” to “Commercial Passenger Fishing Vessel” to align with industry standards in order to prevent confusion.
  - Add approximately 330 Commercial Passenger Fishing Vessels carrying six passengers of less based on California Department of Fish and Wildlife permits.

- Vessel survival: The vessel survival percentages are based on vessel survival curves that CARB staff developed using the age distribution of reported vessels for the year 2015-2018.. Survival curves of vessels, rather than engines, are used based on discussions with industry stakeholders, which show a trend towards rebuilding engines indefinitely instead of repowering.
- Engine population: Vessel scaling factors for each CHC category are applied to the applicable engine data that is reported to the CARB CHC Reporting Database.

<table>
<tr><td>Percent Breakdown of Catamaran, Monohull, and Short Run Ferry</td><td>Table I-J: Breakdown of Ferry Population by Catamaran, Monohull, and Short Run
<table>
<tr><th>Ferry Category</th><th>HP</th><th>Percentage Breakdown</th></tr>
<tr><td>Ferry (Catamaran)</td><td>150,021</td><td>72.6%</td></tr>
<tr><td>Ferry (Monohull)</td><td>46,878</td><td>22.7%</td></tr>
<tr><td>Ferry (Short Run)</td><td>9,703</td><td>4.7%</td></tr>
</table>
CARB staff based the ferry split percentage on an analysis of the CARB CHC Reporting Database.</td></tr>
</table>

Table II-A: Major Cost Inputs by CHC Category—Ferry (Catamaran)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

Unit Engine Capital Cost ($/hp)	$291	$755	$51	$755	**Repower to Tier 3:** Value derived by dividing the Capital Cost of $780,000 with engine hp of 2,680 to get $291/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for this category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for this category. The Ferry survey response category was not sub-categorized into Catamaran, Monohull, or Short Run.
					Repower to Tier 4: Engine Capital Cost and engine hp data were taken from the following sources. The $/hp values were derived by dividing the Engine Capital Cost with the engine hp in each source, and the $/hp values were averaged, resulting in a value of $755/hp.
					• Cal Maritime Study:
					  ○ Average Engine Capital Cost: $2,500,000 (Table 50, page 86)
					  ○ hp: 6,860 (Table 46, page 81, 3,430 hp per main engine * 2 main engines)
					• *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District, December 2019.
					  ○ Engine Capital Cost: $3,978,000 (pages 47-48)
					  ○ hp: (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used)
					• *"VDECS Feasibility Study for AMD Class Vessels,"* Aurora Marine Design for Golden Gate Bridge, Highway and Transportation District, February 2020.
					  ○ Engine Capital Cost: CARB staff subtracted the Labor and Installation Cost ($2,732,889) from the total cost of the vessel

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					($12,804,940) to provide a value of $10,072,015 (page 307 of pdf). o hp: 8,000 (pdf page 8, 4 engines * 2000 hp) o Engine Capital Cost: CARB staff subtracted the Labor and Installation Cost ($2,146,169) from the total cost of the vessel ($9,778,698) to provide a value of $7,632,529 (page 308 of pdf). o hp: 8,000 (pdf page 9, 4 engines * 2000hp) **DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $350,000 (Table 52, page 87) divided by hp of 6,860 (Table 46, page 81, 3,430 hp per main engine * 2 main engines) to get $51/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$150	$470	$1,020	$2,161	**Repower Tier 3**: Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged, resulting in a value of $470/hp: • Cal Maritime Study: o Average Labor and Installation Costs: $7,000,000 (Table 50, page 86) o hp: 6,860 (Table 46, page 81, 3,430 hp per main engine * 2 main engines). • "*EPA Tier 4 Feasibility for Existing Vessels*," Incat Crowther for Golden Gate Bridge, Highway and Transportation District o Labor and Installation Cost: $2,232,048, all costs except Equipment Cost and Loss of Revenue in the reference (page 47)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					○ hp: 9,005 (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used) • *"VDECS Feasibility Study for AMD Class Vessels,"* Aurora Marine Design for Golden Gate Bridge Highway and Transportation District, February 2020. ○ Labor and Installation Cost: $2,732,889 (page 307 of pdf). ○ hp: 8,000 (pdf page 8, 4 engines * 2000 hp) ○ Labor and Installation Cost: $2,146,169 (page 308 of pdf). ○ hp: 8,000 (pdf page 9, 4 engines * 2000hp) **DPF:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $7,000,000 (Table 52, page 87) divided by vessel hp of 6,860 (Table 46, page 81, 3,430 hp per main engine * 2 main engines) to get $1,020/hp. **Vessel Replacement:** Value derived using information in Cal Maritime Study. Vessel Replacement Cost of $20,000,000 (Table 48, page 85) divided by vessel hp of 6,860 (Table 46, page 81, 3,430 p per main engine * 2 main engines). The Unit Engine Capital Cost was subtracted from the Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $2,126/hp.
Unit Operational Cost ($/hp)	$0	-$2.1	$7.4	$7.4	**Repower Tier 3:** CARB staff defined this in terms of fuel costs, and assumed similar costs for pre-Tier 1, Tier 1, 2, and 3 engines. **Repower Tier 4:** Operational Cost and engine hp data were taken from the following sources. The $/hp values for each source were derived by adding maintenance costs, DEF costs, and engine fuel savings adjustments together. The resulting $/hp Operational Cost values from each source were averaged. • Cal Maritime Study: -$3.4/hp ○ Annual Maintenance Cost: $6.7/hp: $45,917 annual maintenance cost (Table 49, page 86) divided by 6,860 hp (Table 46, page 81, 3,430 hp per main engine * 2 main engines). ○ Annual DEF Cost: $5.8/hp: 39.4 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) ○ Annual Main Engine Fuel Savings Cost: -$15.8/hp, taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District,

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					December 2019, as this information was not available in the Cal Maritime Study. • *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District, December 2019: -$0.8/hp o Annual Maintenance Cost: $15/hp: $135,106 (page 17) divided by 9,005 hp (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used). o Annual DEF Cost: N/A o Annual Main Engine Fuel Savings Cost: -$15.8/hp. Total fuel savings cost of -$142,502 (page 17) divided by hp of 9,005 (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used) to get the $/hp value. **DPF:** Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $7.4/hp. CARB staff calculated the DPF Regen Fuel Cost of $6.4/hp by multiplying an average fuel consumption of 39.4 gal/hp/year by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-B: Major Cost Inputs by CHC Category—Ferry (Monohull)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$291	$652	$104	$652	**Repower to Tier 3:** Value derived using Engine Capital Cost of $780,000 with engine hp of 2,680 to get $291/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators by adding together all main and auxiliary Engine Capital Costs that respondents provided for this category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for this category. The ferry survey response category was not sub-categorized into Catamaran, Monohull, or Short Run. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $652/hp:

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

					• Cal Maritime Study:
					  ○ Average Engine Capital Cost: $625,000 (Table 41, page 79)
					  ○ hp: 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines).
					• *"M.S. SONOMA CARB Study Tier 4 Feasibility Report,"* BMT Designers and Planners Inc. for Golden Gate Bridge, Highway, and Transportation District, November 2019.
					  ○ Engine Capital Cost: The total cost of $6,003,669 (Capital, Labor, and Installation) was provided for this vessel (pdf page 26). To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Engine Capital Cost and Labor and Installation Cost of the Monohull Ferry in the Cal Maritime Study and applied it to the total cost in the Golden Gate Ferry Report in order to derive a value of $3,718,842
					  ○ hp: 3,750 (pdf page 7, 2 engines * 1,875hp)
					DPF: Value derived using information in Cal Maritime Study. Average Capital Cost of $208,000 (Table 43, page 80) divided by hp of 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines) to get $104/hp.
					Vessel Replacement: See "Repower to Tier 4" basis above.

Unit Labor and Installation Cost ($/hp)	$150	$401	$140	$1,848	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged: • Cal Maritime Study: ○ Average Labor and Installation Cost: $384,000 (Table 41, page 79)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					○ hp: 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines) • *"M.S. SONOMA CARB Study Tier 4 Feasibility Report,"* BMT Designers and Planners Inc. for Golden Gate Bridge, Highway, and Transportation District, November 2019. ○ Labor and Installation Cost: The total cost of $6,003,669 (Capital, Labor, and Installation) was provided for this vessel (pdf page 26). To separate the Labor and Installation Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Costs of the Monohull Ferry in the Cal Maritime Study and applied it to the total cost in the Golden Gate Ferry Report in order to derive a value of $2,284,857. ○ hp: 3,750 (pdf page 7, 2 engines * 1,875hp) **DPF:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $208,000 (Table 43, page 80) divided by vessel hp of 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines) to get $140/hp. **Vessel Replacement:** Value derived using information in Cal Maritime Study. Vessel Replacement Cost of $5,000,000 (Table 39, page 78) divided by vessel hp of 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines) to get a Unit Vessel Replacement Cost of $2,500 .The Unit Engine Capital Cost was subtracted from the Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $1,848.
Unit Operational Cost ($/hp)	$0	-$3.4	$7.4	$7.4	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: -$3.4/hp ○ Annual Maintenance Cost: $6.7/hp: $13,387 annual maintenance cost (Table 41, page 79) divided by 2,000 hp (Table 37, page 71, 1,000 hp per main engine * 2 main engines).

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					○ Annual DEF Cost: $5.8/hp: 39.4 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) ○ Annual Main Engine Fuel Savings Cost: -$15.8/hp. Value taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District, as this information was not available in the Cal Maritime Study. Total fuel savings cost of -$142,502 (page 17) was divided by hp of 9,005 (page 10, 1,680kW per engine * 4 engines * 1.34kW to hp conversion factor, new, replaced engine hp was used) to get the $/hp value. **DPF:** Operational Costs includes DPF Regen Fuel Cost and DPF Cleaning Cost. CARB staff calculated the DPF Regen Fuel Cost of $6.4/hp by multiplying an average fuel consumption of 39.4 gal/hp/year (extracted from the engine inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-C: Major Cost Inputs by CHC Category—Pilot Boat

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$366	$76	$366	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived the Unit Engine Capital Cost by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

					provided for each category. See each vessel category table for more information about how the $/hp values were derived.
					Repower to Tier 4: Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get a value of $366/hp:
					• Cal Maritime Study:
					  ○ Average Engine Capital Cost: $624,500 (Table 84, page 118)
					  ○ hp: 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines).
					• Port of Los Angeles comment letter to Tracy Haynes (CARB) dated April 30, 2020.
					  ○ Engine Capital Cost: The total cost (Capital, Labor, and Installation, vessel lengthening, purchasing the equipment to lengthen the vessels, extending existing piers) was provided for this vessel. To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Pilot Boat in the Cal Maritime Study and applied it to the total cost in the comment letter in order to derive a value of $592,451.
					  ○ hp: 1,628
					DPF: Value derived using information in Cal Maritime Study. Average Capital Cost of $130,000 (Table 86, page 119) divided by hp of 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines) to get $76/hp.
					Vessel Replacement: See “Repower to Tier 4” basis above.

Unit Labor and Installation Cost ($/hp)	$150	$444	$369	$2,512	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

					Repower to Tier 4: Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged for a value of $444/hp:
					• Cal Maritime Study:
					  ○ Average Labor and Installation Cost: $759,000 (Table 84, page 118)
					  ○ hp: 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines).
					• Port of Los Angeles comment letter to Tracy Haynes (CARB) dated April 30, 2020.
					  ○ Labor and Installation Cost: The total cost (Capital, Labor, and Installation, vessel lengthening, purchasing the equipment to lengthen the vessels, extending existing piers) was provided for this vessel. To separate the Capital Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Pilot Boat in the Cal Maritime Study and applied it to the total cost in the comment letter in order to derive a value of $720,049.
					  ○ hp: 1,628
					DPF: Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $628,000 (Table 86, page 119) divided by hp of 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines) to get $369/hp.
					Vessel Replacement: The Unit Vessel Replacement Cost and hp data were taken from the following sources, and $/hp values were averaged. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost.
					• Cal Maritime Study Vessel Replacement Cost of $5,000,000 (Table 39, page 78) divided by vessel hp of 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines).
					• Port of Los Angeles comment letter to Tracy Haynes (CARB) dated April 30, 2020. Vessel Replacement Cost of $3,364,462 divided by vessel hp of 1,628 to get $2,076/hp.
					• San Francisco Bar Pilot Association comment letter to David Quiros dated April 30, 2020. Values are for ocean station vessels, and exclude

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					the DPF retrofit cost. Vessel Replacement Cost of $12,000,000 divided by vessel hp of 2,200 to get $5,009/hp. • San Francisco Bar Pilot Association comment letter to David Quiros dated April 30, 2020. Values are for high speed Pilot Vessels, and exclude the DPF retrofit cost. Vessel Replacement Cost of $6,500,000 divided by vessel hp of 1,700 to get $3,378/hp. • San Francisco Bar Pilot Association comment letter to David Quiros dated April 30, 2020. Values are for high speed Pilot Vessels, and exclude the DPF retrofit cost. Vessel Replacement Cost of $1,000,000 divided by vessel hp of 330 to get $2,584/hp. • Jacobsen Pilot Service, Inc. comment letter to David Quiros (CARB) dated April 30, 2020. Vessel Replacement Cost of $4,300,000 divided by vessel hp of 1,930 (extracted from the CARB CHC Reporting Database) to get $2,228/hp.
Unit Operational Cost ($/hp)	$0	-$4.5	$8.1	$8.1	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: -$4.5/hp o Annual Maintenance Cost: $6.7/hp: $11,379 annual maintenance cost (Table 83, page 118) divided by 1,700 hp (Table 80, page 113, 850 hp per main engine * 2 main engines). o Annual DEF Cost: $6.4/hp: 43.9 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon). o Annual Main Engine Fuel Savings Cost: -$17.6/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					DPF: Operational Costs includes DPF Regen Fuel Cost and DPF Cleaning Cost. CARB staff calculated the DPF Regen Fuel Cost of $7.1/hp by multiplying an average fuel consumption of 43.9 gal/hp/year by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-D: Major Cost Inputs by CHC Category— Push/Tow Tug

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

Unit Engine Capital Cost ($/hp)	$170	$491	$104	$491	**Repower to Tier 3:** Value derived using Engine Capital Cost of $574,000 with engine hp of 3,380 to get $170/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Push/Tow Tug Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Push/Tow Tug Vessels.
					Repower to Tier 4: Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $491/hp:
					• Cal Maritime Study:
					  ○ Average Engine Capital Cost: $625,000 (Table 66, page 102)
					  ○ hp: 2,000 (Table 62, page 95, 1000 hp per main engine * 2 main engines).
					• R.E. Staite Engineering Inc., comment letter attachment to David Quiros (CARB) dated April 30, 2020.
					  ○ Engine Capital Cost: $2,766,268
					  ○ hp: 4,000
					• Sause Bros. Inc. comment letter attachment to David Quiros (CARB) dated April 30, 2020.
					  ○ Engine Capital Cost: CARB staff averaged the Replacement (Incidental) costs provided for Ocean Going Tug vessels to get $2,237,420. To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					and Installation Cost of the Push/Tow Tug in the R.E. Staite Engineering Inc. comment letter and applied it to the total cost in the Sause Bros. Inc. comment letter in order to derive a value of $2,075,193. o hp: The average hp provided from the Ocean Going Tug vessels is used—4,439. **DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $208,000 (Table 68, page 102) divided by hp of 2,000 (Table 62, page 95, 1000 hp per main engine * 2 main engines) to get $104/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$204	$96	$132	$2,845	**Repower to Tier 3:** Value derived using Labor and Installation Cost of $691,100 with engine hp of 3,380 to get $204/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Push/Tow Tug Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Push/Tow Tug Vessels. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $96/hp: • Cal Maritime Study: o Average Labor and Installation Cost: $396,000 (Table 66, page 102) o hp: 2,000 (Table 62, page 95, 1000 hp per main engine * 2 main engines). • R.E. Staite Engineering Inc., comment letter attachment to David Quiros (CARB) dated April 30, 2020. o Labor and Installation Cost: $216,252 o hp: 4,000 • Sause Bros. Inc. comment letter attachment to David Quiros (CARB) dated April 30, 2020. o Labor and Installation Cost: CARB staff averaged the total vessel costs for the Ocean Going Tug Vessels to get $2,237,420. To separate the Labor and Installation Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Push/Tow Tug in the R.E. Staite Engineering Inc.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					comment letter and applied it to the total cost in the Sause Bros Inc. comment letter in order to derive a value of $162,227. ○ hp: The average hp provided from the Ocean Going Tug vessels is used—4,439. **DPF:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $264,000 (Table 68, page 102) divided by hp of 2,000 (Table 62, page 95, 1000 hp per main engine * 2 main engines) to get $132/hp. **Vessel Replacement:** The Unit Vessel Replacement Cost and hp data were taken from the following sources, and $/hp values were averaged. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $2,845. • Cal Maritime Study Vessel Replacement Cost of $6,000,000 (Table 64, page 101) divided by vessel hp of 2,000 (Table 62, page 95, 1,000 hp per main engine * 2 main engines) to get $3,000/hp. • Sause Bros. Inc. attachment to comment letter to David Quiros (CARB) dated April 30, 2020. Vessel Replacement Cost of $16,300,000 divided by vessel hp of 4,439 to get $3,672/hp.
Unit Operational Cost ($/hp)	$0	-$0.2	$5.3	$5.3	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: -$0.2/hp ○ Annual Maintenance Cost: $6.7/hp: $13,387 annual maintenance cost (Table 65, page 101) divided by 2,000 hp (Table 62, page 95, 1,000 hp per main engine * 2 main engines). ○ Annual DEF Cost: $3.9/hp: 26.9 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) ○ Annual Main Engine Fuel Savings Cost: -$10.8/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational Costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $5.3/hp. CARB staff calculated the DPF Regen Fuel Cost of $4.3/hp by multiplying an average fuel consumption of 26.9 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-E: Major Cost Inputs by CHC Category—Escort/Ship Assist Tug

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$443	$51	$443	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $443/hp: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 20, 2020 and May 6, 2020. ○ Engine Capital Cost: $3,800,000 ○ hp: 6,850. The hp of the Escort/Ship Assist Tug in the Cal Maritime Study is used to represent the vessel, since hp

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					information was not provided (Table 53, page 88, 3,425 hp per main engine * 2 main engines). • The American Waterways Operators comment letter to David Quiros (CARB) dated April 30, 2020. o Engine Capital Cost: The total cost was provided for the whole vessel. To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Escort/Ship Assist Tug in the emails from Daniel Smith (Crowley Maritime) and applied it to the total cost in The American Waterways Operators comment letter in order to derive a value of $2,901,961. o hp: 6,850. The hp of the Escort/Ship Assist Tug in the Cal Maritime Study is used to represent the vessel, since hp information was not provided (Table 53, page 88, 3,425 hp per main engine * 2 main engines). • Cal Maritime Study: o Average Engine Capital Cost: $2,400,000 (Table 57, page 93) o hp: 6,850 (Table 53, page 88, 3,425 hp per main engine * 2 main engines). **DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $350,000 (Table 59, page 94) divided by hp of 6,850 (Table 53, page 88, 3425 hp per main engine * 2 main engines) to get $51/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$150	$110	$39	$1,747	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

					Repower to Tier 4: Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $110/hp:
					• Emails from Daniel Smith at Crowley to David Quiros (April 29, 2020 and May 6, 2020)
					  ○ Labor and Installation Cost: $1,045,000
					  ○ hp: 6,850. The hp of the Escort/Ship Assist Tug in the Cal Maritime Study is used to represent the vessel, since hp information was not provided.
					• The American Waterways Operators comment letter to David Quiros (CARB) dated April 30, 2020.
					  ○ Labor and Installation Cost: The total cost was provided for the whole vessel. To separate the Labor and Installation Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Escort/Ship Assist Tug in the Daniel Smith (Crowley Maritime) and applied it to the total cost in The American Waterways Operators comment letter in order to derive a value of $798,039.
					  ○ hp: 6,850. The hp of the Escort/Ship Assist Tug in the Cal Maritime Study is used to represent the vessel, since hp information was not provided (Table 53, page 88, 3,425 hp per main engine * 2 main engines).
					• Cal Maritime Study:
					  ○ Average Labor and Installation Cost: $412,000 (Table 57, page 93)
					  ○ hp: 6,850 (Table 53, page 88, 3,425 hp per main engine * 2 main engines).
					DPF: Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $264,000 (Table 59, page 94) divided by hp of 6,850 (Table 53, page 88, 3425 hp per main engine * 2 main engines) to get $39/hp.
					Vessel Replacement: CARB staff derived the average Unit Vessel Replacement Cost from the following source, and subtracted the Unit Engine Capital Cost from this value to provide the Unit Labor and Installation Cost of $1,747/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					• Cal Maritime Study: Vessel Replacement Cost of $15,000,000 (Table 55, page 92) divided by hp of 6,850 (Table 53, page 88, 3,425 hp per main engine * 2 main engines).
Unit Operational Cost ($/hp)	$0	$2.8	$3.5	$3.5	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: $2.8/hp o Annual Maintenance Cost: $6.7/hp: $45,850 annual maintenance cost (Table 56, page 93) divided by 6,850 hp (Table 53 page 88, 3,425 hp per main engine * 2 main engines). o Annual DEF Cost: $2.3/hp: 15.4 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$6.2/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost, for a total of $3.5/hp. CARB staff calculated the DPF Regen Fuel Cost of $2.5/hp by multiplying an average fuel consumption of 15.4 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-F: Major Cost Inputs by CHC Category—ATB Tug

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$328	$31	$328	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived the Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Engine Capital Cost and engine hp data were taken from the following source to: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 20, 2020 and May 6, 2020. Cost information for two ATB Tug repowers was provided, and the information was averaged to derive the $190/hp value. The Engine Capital Cost information included the cost of the DPF retrofit; CARB staff deducted the DPF retrofit cost to get the costs as follows: o Engine Capital Cost: $3,605,725 o hp: 10,963 o Engine Capital Cost: $3,969,957 o hp: 12,102 **DPF:** Cost information for a single engine was provided by Daniel Smith (Crowley Maritime) to Wei Liu (CARB) in an email dated June 10, 2020. CARB staff multiplied the DPF Capital Cost of $160,000 by the number of engines (2) to get $320,000, and divided by 10,190 hp to get $31/hp. **Vessel Replacement:** See “Repower to Tier 4” basis above.
Unit Labor and Installation Cost ($/hp)	$150	$96	$108	$5,262	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp were derived. **Repower to Tier 4:** Labor and Installation Costs and engine hp data were taken from the following source: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 20, 2020 and May 6, 2020. Cost information for two ATB Tug repowers was provided, and the information was averaged to derive the $/hp value. ○ Labor and Installation Cost: $1,100,000 ○ hp: 10,963 ○ Labor and Installation Cost: $1,100,000 ○ hp: 12,102 **DPF:** CARB staff assumed the same Labor and Installation Cost as the "Repower to Tier 4" scenario above, and divided $1,100,000 by 10,190 hp to get $108/hp. **Vessel Replacement:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff averaged the Unit Vessel Replacement Cost for Ferry (Catamaran, $2,915), Ferry (Monohull, $2,500), Pilot Boat ($2,878), Push/Tow Tug ($3,336), Commercial Passenger Fishing ($2,770), Dredge ($7,347), ATB Barge ($20,548), Crew Supply ($2,116), and Workboat ($5,902) vessels to get $5,590/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $5,262.
Unit Operational Cost ($/hp)	$0	-$1.7	$6.3	$6.3	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: -$1.7/hp

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					○ Annual Maintenance Cost: $6.7/hp: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. ○ Annual DEF Cost: $4.8/hp: 33 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) ○ Annual Main Engine Fuel Savings Cost: -$13.2/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $6.3/hp. CARB staff calculated the DPF Regen Fuel Cost of $5.3/hp by multiplying an average fuel consumption of 33 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-G: Major Cost Inputs by CHC Category— Research Vessel

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$286	$80	$286	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from results of 2019 CARB survey

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,269/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($474/hp), Crew Supply ($499/hp) and Workboat ($579/hp) to get $687/hp. Staff assumed the same split of Capital and Labor and Installation Cost as the Excursion Vessel to get $288/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,071/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($446/hp), Push/Tow Tug ($236/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($4244/hp) and Workboat ($267/hp) to get $335/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the Excursion Vessel to get $80/hp. **Vessel Replacement:** See “Repower to Tier 4” basis above.
Unit Labor and Installation Cost ($/hp)	$150	$396	$255	$5,304	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Unit Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp were derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,269/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($474/hp), Crew Supply ($499/hp) and Workboat ($579/hp) to get $687/hp. Staff assumed the same split of Capital and Labor and Installation Cost as the Excursion Vessel to get $399/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,071/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($446/hp), Push/Tow Tug ($236/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($4244/hp) and Workboat ($267/hp) to get $335/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the Excursion Vessel to get $255/hp. **Vessel Replacement:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff averaged the Unit Vessel Replacement Cost for Ferry (Catamaran, $2,915), Ferry (Monohull, $2,500), Pilot Boat ($2,878), Push/Tow Tug ($3,336), Commercial Passenger Fishing ($2,770), Dredge ($7,347), ATB Barge ($20,548), Crew Supply ($2,116), and Workboat ($5,902) vessels to get $5,590/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $5,262.
Unit Operational Cost ($/hp)	$0	$2.1	$3.9	$3.9	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: $2.1/hp ○ Annual Maintenance Cost: $6.7/hp: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					○ Annual DEF Cost: $2.6/hp: 17.9 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) ○ Annual Main Engine Fuel Savings Cost: -$7.2/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost, for a total of $3.9/hp. CARB staff calculated the DPF Regen Fuel Cost of $2.9/hp by multiplying an average fuel consumption of 17.9 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-H: Major Cost Inputs by CHC Category—Commercial Passenger Fishing

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$141	$286	$80	$286	**Repower to Tier 3:** Value derived using Engine Capital Cost of $60,000 with engine hp of 425 to get $141/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Commercial Passenger Fishing, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Commercial Passenger Fishing. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,269/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($474/hp), Crew Supply

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					($499/hp) and Workboat ($579/hp) to get $687/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the Excursion Vessel to get $288/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,071/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($446/hp), Push/Tow Tug ($236/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($4244/hp) and Workboat ($267/hp) to get $335/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the Excursion Vessel to get $80/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$188	$396	$255	$2,484	**Repower to Tier 3:** Value derived using Labor and Installation Cost of $80,000 with engine hp of 425 to get $188/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Commercial Passenger Fishing, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Commercial Passenger Fishing. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,269/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($474/hp), Crew Supply ($499/hp) and Workboat ($579/hp) to get $687/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the Excursion Vessel to get $399/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,071/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($446/hp), Push/Tow Tug ($236/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($4244/hp) and Workboat ($267/hp) to get $335/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the Excursion Vessel to get $255/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Vessel Replacement: CARB staff derived the average Unit Vessel Replacement Cost from the following sources, and subtracted the Unit Engine Capital Cost from this value to provide the Unit Labor and Installation Cost of $2,482. • Cal Maritime Study: Vessel Replacement Cost of $1,300,000 (page 61) divided by hp of 1,000 (Table 26, page 57, 500 hp per main engine * 2 main engines) to get $1,300/hp. • Ken Franke (Sportfishing Association of California) to David Quiros (CARB) in an attachment to an email dated June 29, 2020. CARB staff averaged Vessel Replacement Cost and engine hp information for 101 vessels. Vessel Replacement Costs ranged from $180,000 to $8,000,000, and hp per engine ranged from 200 to 1100.
Unit Operational Cost ($/hp)	$0	$1.8	$4.1	$4.1	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: $1.8/hp o Annual Maintenance Cost: $6.7/hp: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value. o Annual DEF Cost: $2.8/hp: 19.2 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) o Annual Main Engine Fuel Savings Cost: -$7.7/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					DPF: Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $4.1/hp. CARB staff calculated the DPF Regen Fuel Cost of $3.1/hp by multiplying an average fuel consumption of 19.2 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-I: Major Cost Inputs by CHC Category—Excursion

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$381	$262	$83	See Table III	**Repower to Tier 3:** Value derived using Engine Capital Cost of $2,281,556 with engine hp of 5994 to get $381/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Excursion Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Excursion Vessels. **Repower to Tier 4:** Value derived using information in Cal Maritime Study. Average Engine Capital Cost of $301,000 (Table 32, page 69) divided by hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $262/hp. **DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $96,000 (Table 34, page 70) divided by main engine hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $83/hp. **Vessel Replacement:** See "Table III: Major Cost Inputs— Cost Inputs for Zero Emissions and Advanced Technology (Short Run Ferry and Excursion)."
Unit Labor and Installation Cost ($/hp)	$41	$363	$264	See Table III	**Repower to Tier 3:** Value derived using Labor and Installation Cost of $248,500 with engine hp of 5994 to get $41/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Excursion Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Excursion Vessels.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Repower to Tier 4: Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $417,000 (Table 32, page 69) divided by main engine hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $363/hp. **DPF:** Value derived using information in Cal Maritime Study. Average Labor and Installation Cost of $304,000 (Table 34, page 70) divided by main engine hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $264/hp. **Vessel Replacement:** See "Table III: Major Cost Inputs— Cost Inputs for Zero Emissions and Advanced Technology (Shor Run Ferry and Excursion)."

Unit Operational Cost ($/hp)	$0	$3.7	$2.9	See Table III	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines.
					Repower to Tier 4: Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together.
					• Cal Maritime Study: $3.7/hp
					  ○ Annual Maintenance Cost: $6.7/hp: $7,697 annual maintenance cost (Table 31, page 68) divided by 1,150 hp (Table 28 page 63, 575 hp per main engine * 2 main engines).
					  ○ Annual DEF Cost: $1.7/hp: 11.5 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon)
					  ○ Annual Main Engine Fuel Savings Cost: -$4.6/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory.
					DPF: Operational Costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $2.9/hp. CARB staff calculated the DPF Regen Fuel Cost of $1.9/hp by multiplying an average fuel consumption of 11.5 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Table III: Major Cost Inputs— Cost Inputs for Zero Emissions and Advanced Technology (Shor Run Ferry and Excursion)."

Table II-J: Major Cost Inputs by CHC Category—Dredge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$261	$223	$82	$223	**Repower to Tier 3:** Value derived using Engine Capital Cost of $560,850 with engine hp of 2150 to get $261/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Dredge Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Dredge Vessels. **Repower to Tier 4:** Value derived using information in Cal Maritime Study. Average Engine Capital Cost of $516,000 (Table 19, page 49) divided by main engine hp of 2,314 ((Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp) to get $223/hp. **DPF:** Value derived using information in Cal Maritime Study. Average Capital Cost of $189,500 (Table 21, page 50) divided by vessel hp of 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp) to get $82/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$270	$251	$194	$7,124	**Repower to Tier 3:** Value derived using engine Labor and Installation Cost of $581,000 with engine hp of 2150 to get $270/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Dredge Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Dredge Vessels. **Repower to Tier 4:** Value derived using information in the Cal Maritime Study. Average Labor and Installation Cost of $581,000 (Table 19, page 49) divided by main engine hp of 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp) to get $251/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					DPF: Value derived using information in the Cal Maritime Study. Average Labor and Installation Cost of $449,000 (Table 21, page 50) divided by vessel hp of 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp) to get $194/hp. **Vessel Replacement:** CARB staff derived the average Unit Vessel Replacement Cost from the following source, and subtracted the Unit Engine Capital Cost from this value to provide the Unit Labor and Installation Cost of $7,124/hp. • Cal Maritime Study: Vessel Replacement Cost of $17,000,000 (Table 17, page 48) divided by hp of 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp).
Unit Operational Cost ($/hp)	$0	-$4.4	$8.0	$8.0	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: -$4.4/hp ○ Annual Maintenance Cost: $6.7/hp: $10,040 annual maintenance cost (Table 18, page 49) divided by 2,314 hp (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kW=256 hp, and 155kW=208 hp). ○ Annual DEF Cost: $6.3/hp: 43.3 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) ○ Annual Main Engine Fuel Savings Cost: -$17.4/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $8/hp. CARB staff calculated the DPF Regen Fuel Cost of $7/hp by multiplying an average fuel consumption of 43.3 gal/hp/year (extracted from the

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp)" for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-K: Major Cost Inputs by CHC Category—ATB Barge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$421	$692	$103	$692	**Repower to Tier 3:** Value derived by taking an average of the $/hp from the following two sources to get $421/hp: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 20, 2020 and May 6, 2020. CARB staff took the average cost of the Crowley 550 barges with engines <=600kW, and subtracted the DPF retrofit cost of $405,000 (see DPF explanation below for more information) to get an Engine Capital Cost of $1,395,900, divided by engine hp of 2,419. • Sause Bros. Inc. comment letter attachment to David Quiros (CARB) dated April 30, 2020. Engine Capital Cost of $617,364 divided by engine hp of 2,320. The average horsepower and average costs from the provided vessels are used to calculate the unit costs. The Tank Barges in the letter are categorized as ATB Barges in the cost analysis. Total cost was provided for the whole vessel. CARB staff assumed the same split of Engine Capital and Labor and Installation Cost as the Crowley Maritime ATB Barges. **Repower to Tier 4:** Engine Capital Cost and engine hp data were provided in emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 20, 2020 and May 6, 2020. The average hp for the Crowley 650 barges and average cost are used to calculate the unit cost for engines >600kW. The total cost for the engine repower included the DPF retrofit cost of $135,000, which CARB staff deducted to get the Engine Capital Cost. • Engine Capital Cost: $2,665,000 • hp: 3,849

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					DPF: Value derived by taking an average of the $/hp from the following sources to get $103/hp. • Cal Maritime Study. Capital Cost of $308,000 (Table 13, Page 38) divided by hp of 2,920 (Table 9, page 29, sum of 4 engines * 460hp, 2 engines * 270 hp, and 1 engine * 80hp). • Daniel Smith (Crowley Maritime) to Wei Liu (CARB) in an email dated June 10, 2020. The Capital Cost for a single engine was provided; CARB staff multiplied this by the total number of engines (9 for 550 ATB Barges) to get $405,000, divided by hp of 2,419. • Daniel Smith (Crowley Maritime) to Wei Liu (CARB) in an email dated June 10, 2020. The Capital Cost for a single engine was provided; CARB staff multiplied this by the total number of engines (3 for 650 ATB Barges) to get $135,000, divided by hp of 3,849 **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$91	$130	$225	$19,856	**Repower to Tier 3:** Value derived by taking an average of the $/hp from the following two sources to get $91/hp: • Emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 20, 2020 and May 6, 2020. CARB staff took the average Labor and Installation Cost of Crowley 550 barges with engines <=600kW to get $300,000, divided by the average hp of 2,419. • Sause Bros. Inc. comment letter attachment to David Quiros (CARB) dated April 30, 2020. Labor and Installation Cost of $132,766 divided by hp of 2,320. The average hp and average costs from the provided vessels are used to calculate the unit costs. The Tank Barges in the letter are categorized as ATB Barges in the cost analysis. Total cost was provided for the whole vessel. CARB staff assumed the same split of Engine Capital and Labor and Installation Cost as the Crowley Maritime ATB Barges. **Repower to Tier 4:** Labor and Installation Cost and hp data were provided in emails from Daniel Smith (Crowley Maritime) to David Quiros (CARB) dated April 20, 2020 and May 6, 2020. The average hp for the Crowley 650 barges and average Labor and Installation Costs are used to calculate the unit cost for Engine >600kW. • Labor and Installation: $500,000

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					• hp: 3,849 **DPF:** Value derived by taking an average of the $/hp from the following sources to get $225/hp. • Cal Maritime Study. Labor and Installation Cost of $666,000 (Table 13, Page 38) divided by hp of 2,920 (Table 9, page 29, sum of 4 engines * 460hp, 2 engines * 270 hp, and 1 engine * 80hp). • Daniel Smith (Crowley Maritime) to Wei Liu (CARB) in an email dated June 10, 2020. The Labor and Installation Cost of $666,000 from the Cal Maritime study was used divided by hp of 2,419. • The Labor and Installation Cost of $666,000 from the Cal Maritime study was used, and divided by the average hp of 3,849 for the Crowley 650 barges (see "Repower to Tier 4" for reference). **Vessel Replacement:** CARB staff derived the average Unit Vessel Replacement Cost from the following source, and subtracted the Unit Engine Capital Cost from this value to provide the Unit Labor and Installation Cost of $19,856/hp. Cal Maritime Study: Vessel Replacement Cost of $60,000,000 (Table 11, page 37) divided by hp of 2,920 (Table 9, page 29, sum of 4 engines * 460hp, 2 engines * 270 hp, and 1 engine * 80hp)

Unit Operational Cost ($/hp)	$0	$0.7	$4.8	$4.8	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines.
					Repower to Tier 4: Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together.
					• Cal Maritime Study: $0.7/hp
					  ○ Annual Maintenance Cost: $6.7/hp: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value.
					  ○ Annual DEF Cost: $3.4/hp: 23.4 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon)

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					○ Annual Main Engine Fuel Savings Cost: -$9.4/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $4.8/hp. CARB staff calculated the DPF Regen Fuel Cost of $3.8/hp by multiplying an average fuel consumption of 23.4 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-L: Major Cost Inputs by CHC Category—Bunker Barge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$575	$105	$575	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran,

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					$1,224/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($474/hp), Crew Supply ($499/hp) and Workboat ($579/hp) to get $687/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the ATB Barge to get $579/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,071/hp), Ferry (Monohull, $244/hp), Pilot Boat ($446/hp), Push/Tow Tug ($236/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($244/hp) and Workboat ($267/hp) to get $335/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the ATB Barge to get $105/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$150	$108	$230	$5,015	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Labor and Installation information was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp were derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and Installation Costs for Ferry (Catamaran, $1,269/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($474/hp), Crew Supply ($499/hp) and Workboat ($579/hp) to get $687/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the ATB Barge to get $109/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,071/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($446/hp), Push/Tow Tug ($236/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($4244/hp) and Workboat ($267/hp) to get $335/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the ATB Barge to get $230/hp. **Vessel Replacement:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff averaged the Unit Vessel Replacement Cost for Ferry (Catamaran, $2,915), Ferry (Monohull, $2,500), Pilot Boat ($2,878), Push/Tow Tug ($3,336), Commercial Passenger Fishing ($2,770), Dredge ($7,347), ATB Barge ($20,548), Crew Supply ($2,116), and Workboat ($5,902) vessels to get $5,590/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $5,262.

Unit Operational Cost ($/hp)	$0	$3.7	$2.9	$2.9	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines.
					Repower to Tier 4: Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together.
					• Cal Maritime Study: $3.7/hp
					  ○ Annual Maintenance Cost: $6.7/hp: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value.
					  ○ Annual DEF Cost: $1.7/hp: 11.5 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon)
					  ○ Annual Main Engine Fuel Savings Cost: -$4.6/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $2.9/hp. CARB staff calculated the DPF Regen Fuel Cost of $1.9/hp by multiplying an average fuel consumption of 11.5 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-M: Major Cost Inputs by CHC Category—Other Barge

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$575	$105	$575	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived Unit Engine Capital Cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,224/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($474/hp), Crew Supply ($499/hp) and Workboat ($579/hp) to get $687/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the ATB Barge to get $579/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					DPF: Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,071/hp), Ferry (Monohull, $244/hp), Pilot Boat ($446/hp), Push/Tow Tug ($236/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($244/hp) and Workboat ($267/hp) to get $335/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the ATB Barge to get $105/hp. **Vessel Replacement:** See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$150	$108	$230	$5,015	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Labor and Installation Cost was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,269/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($810/hp), Escort ($553/hp), ATB Tug ($424/hp), Excursion ($624/hp), Dredge ($474/hp), Crew Supply ($499/hp) and Workboat ($579/hp) to get $687/hp. Staff assumed the same split of Capital and Labor and Installation Cost as the ATB Barge to get $109/hp. **DPF:** Cost information for this vessel category was not provided by industry stakeholders or the Cal Maritime Study. CARB staff took an average of the total Unit Capital, Labor, and installation Costs for Ferry (Catamaran, $1,071/hp), Ferry (Monohull, $1,053/hp), Pilot Boat ($446/hp), Push/Tow Tug ($236/hp), Escort ($90/hp), ATB Tug ($139/hp), Excursion ($348/hp), Dredge ($276/hp), ATB Barge ($328/hp), Crew Supply ($4244/hp) and Workboat ($267/hp) to get $335/hp. CARB staff assumed the same split of Capital and Labor and Installation Cost as the ATB Barge to get $230/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Vessel Replacement: Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff averaged the Unit Vessel Replacement Cost for Ferry (Catamaran, $2,915), Ferry (Monohull, $2,500), Pilot Boat ($2,878), Push/Tow Tug ($3,336), Commercial Passenger Fishing ($2,770), Dredge ($7,347), ATB Barge ($20,548), Crew Supply ($2,116), and Workboat ($5,902) vessels to get $5,590/hp. The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $5,262.

Unit Operational Cost ($/hp)	$0	$4.8	$2.2	$2.2	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines.
					Repower to Tier 4: Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together.
					• Cal Maritime Study: $4.8/hp
					  ○ Annual Maintenance Cost: $6.7/hp: The maintenance cost information was not available for this category, CARB staff averaged the $/hp values for the Pilot Boat, Push/Tow Tug, Escort/Ship Assist Tug, Excursion, Dredge, Crew Supply, and Workboat to get the value.
					  ○ Annual DEF Cost: $1.1/hp: 7.6 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon)
					  ○ Annual Main Engine Fuel Savings Cost: -$3.0/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory.
					DPF: Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost for a total of $2.2/hp. CARB staff calculated the DPF Regen Fuel Cost of $1.2/hp by multiplying an average fuel consumption of 7.6 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-N: Major Cost Inputs by CHC Category—Crew Supply

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

Unit Engine Capital Cost ($/hp)	$176	$237	$85	$237	**Repower to Tier 3:** Value derived using Engine Capital Cost of $1,016,145 with engine hp of 5,783 to get $176/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Crew Supply Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Crew Supply Vessels.
					Repower to Tier 4: Engine Capital Cost and engine hp data were taken from the following sources, and $/hp values were averaged to get $237/hp:
					• Cal Maritime Study:
					  ○ Average Engine Capital Cost: $451,500 (Table 75, page 110)
					  ○ hp: 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines).
					• Email from Tom Croft (C&C Boats, Inc.) to Tracy Haynes (CARB) dated March 12, 2020.
					  ○ Engine Capital Cost: The total cost was provided for the whole vessel. To separate the Engine Capital Cost, CARB staff looked at the percentage breakdown of Engine Capital Cost and Labor and Installation Cost of the Crew Supply vessel in the Cal Maritime Study and applied it to the total cost in the C&C Boats, Inc. email in order to derive a value of $415,637.
					  ○ hp: 1,996. CARB staff took an average of the hp values provided from C&C Boats, Inc.
					DPF: Value derived using information in Cal Maritime Study. Average capital cost of $144,000 (Table 77, page 111) divided by main engine hp of 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines).

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					Vessel Replacement: See "Repower to Tier 4" basis above.
Unit Labor and Installation Cost ($/hp)	$107	$262	$159	$1,880	**Repower to Tier 3:** Value derived using engine capital cost of $620,000 with engine hp of 5,783. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Crew Supply Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Crew Supply Vessels. **Repower to Tier 4:** Labor and Installation Cost and engine hp data were taken from the following sources, and $/hp values were averaged: • Cal Maritime Study: o Average Labor and Installation Cost: $499,000 (Table 75, page 110) o hp: 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines). • Email from Tom Croft (C&C Boats, Inc.) to Tracy Haynes (CARB) dated March 12, 2020. o Labor and Installation Cost: The total cost was provided for the whole vessel. To separate the Labor and Installation Cost, CARB staff looked at the percentage breakdown of Capital Cost and Labor and Installation Cost of the Crew Supply vessel in the Cal Maritime Study and applied it to the total cost from C&C Boats, Inc. in order to derive a value of $459,363. o hp: 1,996. CARB staff took an average of the hp values provided from C&C Boats, Inc. **DPF:** Value derived using information in Cal Maritime Study. Average capital cost of $271,000 (Table 77, page 111) divided by main engine hp of 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines). **Vessel Replacement:** Value derived using information in the Cal Maritime Study. Combined costs for Workboat and Special Use are used to represent the Workboat. Vessel Replacement Cost of $3,600,000 (Table 73, page 109) divided by hp of 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines). The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $1,880/hp.

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis

Unit Operational Cost ($/hp)	$0	$0.8	$4.7	$4.7	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines.
					Repower to Tier 4: Operational Cost and engine hp data were taken from the following source. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together.
					• Cal Maritime Study: $0.8/hp
					  ○ Annual Maintenance Cost: $6.7/hp: $11,385 annual maintenance cost (Table 74, page 110) divided by 1,701 hp (Table 71, page 104, 567 hp per main engine * 3 main engines).
					  ○ Annual DEF Cost: $3.4/hp: 22.9 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon)
					  ○ Annual Main Engine Fuel Savings Cost: -$9.2/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory.
					DPF: Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost. CARB staff calculated the DPF Regen Fuel Cost of $3.7/hp by multiplying an average fuel consumption of 22.9 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information.
					Vessel Replacement: See "Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-O: Major Cost Inputs by CHC Category—Workboat

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
Unit Engine Capital Cost ($/hp)	$263	$383	$64	$383	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff derived cost information by averaging values for Ferry, Catamaran ($291/hp), Push/Tow Tug ($170/hp), Commercial Passenger Fishing ($141/hp), Excursion ($381/hp), Dredge ($261/hp), ATB Barge ($421/hp), and Crew Supply ($176/hp) categories for a value of $263/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. CARB staff used the Special Use Vessel category to represent the Workboat vessel category. • Average Capital Cost: $575,000 (Table 99, page 132) • hp: 1,500 (Table 95, page 127, 750 hp per main engine * 2 main engines) **DPF:** Value derived using information in the Cal Maritime Study. Combined costs for Workboat and Special Use are used to represent the Workboat. Average Capital Cost of $196,500 (Workboat: Table 93, page 126. Special Use: Table 101, page 133) divided by main engine hp of 3,050 (Workboat: Table 89, page 121, 400 hp per main engine * 2 main engines. Special Use: Table 95, page 127, 750 hp per main engine * 2 main engines + Auxiliary Engine 750 hp). **Vessel Replacement:** See “Repower to Tier 4” basis above.
Unit Labor and Installation Cost ($/hp)	$150	$196	$203	$5,518	**Repower to Tier 3:** Cost information was not provided by industry stakeholders or the Cal Maritime Study. Labor and Installation was derived by averaging values for Push/Tow Tug ($204/hp), Commercial Passenger Fishing ($188/hp), Excursion ($41/hp), Dredge ($270/hp), ATB Barge ($91/hp) and Crew Supply ($107/hp) for a value of $150/hp. These numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for each category, and divided this value by the sum of all main and auxiliary engine hp values that respondents

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					provided for each category. See each vessel category table for more information about how the $/hp values were derived. **Repower to Tier 4:** Cost information was was not provided by industry stakeholders or the Cal Maritime Study. CARB staff used the Special Use Vessel to represent the Workboat Vessel category. Labor and Installation Cost of $294,000 (Table 99, page 132) divided by hp of 1,500 (Table 95, page 127, 750 hp per main engine * 2 main engines) to get $196/hp. **DPF:** Value derived using information in Cal Maritime Study. Combined costs for Workboat and Special Use are used to represent the Workboat. Average labor and Installation Cost of $618,000 (Workboat: Table 93, page 126. Special Use: Table 101, page 133) divided by main engine hp of 3,050 (Workboat: Table 89, page 121, 400 hp per main engine * 2 main engines. Special Use: Table 95, page 127, 750 hp per main engine * 2 main engines + Auxiliary Engine 750 hp). **Vessel Replacement:** Value derived using information in the Cal Maritime Study. Combined costs for Workboat and Special Use are used to represent the Workboat. Vessel Replacement Cost of $18,000,000 (Workboat: Table 91, page 125. Special Use: Table 97, page 131) divided by main engine hp of 3,050 (Workboat: Table 89, page 121, 400 hp per main engine * 2 main engines. Special Use: Table 95, page 127, 750 hp per main engine * 2 main engines + Auxiliary Engine 750 hp). The Unit Engine Capital Cost was subtracted from the average Unit Vessel Replacement Cost to provide the Unit Labor and Installation Cost of $5,518/hp.
Unit Operational Cost ($/hp)	$0	$3.8	$2.9	$2.9	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines. **Repower to Tier 4:** Operational Cost and engine hp data were taken from the following source. The Special Use Vessel category is used to represent the Workboat category. The $/hp value was derived by adding maintenance costs, DEF costs, and engine fuel savings together. • Cal Maritime Study: $3.8/hp ○ Annual Maintenance Cost: $6.7/hp: $10,040 annual maintenance cost (Table 98, page 132) divided by 1,500 hp (Table 95, page 127, 750 hp per main engine * 2 main engines).

	Repower to Tier 3	Repower to Tier 4	DPF	Vessel Replacement	Basis
					○ Annual DEF Cost: $1.7/hp: 11.5 average fuel consumption (gal/hp/year) * 3.75% DEF Consumption Rate * $3.90 diesel fuel cost ($/gallon) ○ Annual Main Engine Fuel Savings Cost: -$4.6/hp. CARB staff assumed the fuel saving costs for Tier 4 repower is similar to the fuel savings for the Ferry (Catamaran), taken from *"EPA Tier 4 Feasibility for Existing Vessels,"* Incat Crowther for Golden Gate Bridge, Highway and Transportation District. The Fuel Savings Cost is scaled to this category based on the fuel consumption per hp data from the engine inventory. **DPF:** Operational costs includes DPF Regen Fuel Cost and DPF Cleaning Cost. CARB staff calculated the DPF Regen Fuel Cost of $1.9/hp by multiplying an average fuel consumption of 11.5 gal/hp/year (extracted from the emission inventory) by a DPF Fuel Penalty Factor of 4.15%. The DPF Cleaning Cost is a constant value of $1/hp. See Table 1 "Constant Values used in Cost Calculations" for more information. **Vessel Replacement:** See "Unit Operational Cost ($/hp) for DPF. CARB staff assumed the vessel replacement includes DPF retrofit.

Table II-P: Major Cost Inputs by CHC Category—Commercial Fishing

	Repower to Tier 3	Basis
Unit Engine Capital Cost ($/hp)	$201	**Repower to Tier 3:** Value derived using Engine Capital Cost of $94,000 divided by hp of 468 to get $201/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all main and auxiliary Engine Capital Costs that respondents provided for Commercial Fishing Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Commercial Fishing Vessels.
Unit Labor and Installation Cost ($/hp)	$85	**Repower to Tier 3:** Value derived using Labor and Installation Cost of $40,000 divided by hp of 468 to get $85/hp. Numbers come from results of 2019 CARB survey of CHC owners/operators. CARB staff added together all Labor and Installation Costs that respondents provided for Commercial Fishing Vessels, and divided this value by the sum of all main and auxiliary engine hp values that respondents provided for Commercial Fishing Vessels.
Unit Operational Cost ($/hp)	$0	**Repower to Tier 3:** CARB staff defined Operational Costs in terms of fuel costs, and assumed that there is no difference in costs between pre-Tier 1, Tier 1, 2, and 3 engines.

Table III: Major Cost Inputs— Cost Inputs for Zero Emissions and Advanced Technology (Short Run Ferry and Excursion)

Vessel Category	Unit Operational Cost ($/hp)	Unit Engine Capital Cost ($/hp)	Unit Labor and Installation Cost ($/hp)	Basis
Ferry (Short Run) Repower	-$53.3	$1,020	$2,380	The Capital, Labor and Installation Cost information is from a PowerPoint presentation, *"Gee's Bend Ferry Battery Conversion*", for retrofitting the ferry to zero emission electric ferry, presented by Tim Aguirre at HMS Ferry on June 7th, 2019. • Operational Cost was derived based on a constant value of -$0.07/hp-hr cost savings from Diesel to Electric multiplied by the total number of hours taken from the engine inventory. • CARB staff assumed 30% of the total cost is Capital Cost, and 70% is the Labor and Installation Cost. • Engine Capital Cost was derived based on a total cost of $1,700,000 divided by engine hp of 500, multiplied by 30%, to get $1,020/hp. • Labor and Installation Cost was derived based on a total cost of $1,700,000 divided by engine hp of 500, multiplied by 70%, to get $2,380/hp.
Ferry (Short Run) New	-$53.3	$1,020	$3,293	Cost information provided by WETA in an internet conference on July 23, 2020 discussing the proposed regulation. The cost information is provided for one vessel with total hp of 830kW, 1113hp.

Vessel Category	Unit Operational Cost ($/hp)	Unit Engine Capital Cost ($/hp)	Unit Labor and Installation Cost ($/hp)	Basis
Excursion, New	-$13.5	$262	$2,126	Cost information was provided by Joe Burgard (Red and White Fleet) to David Quiros (CARB) in an email dated August 19, 2020. Cost information pertains to replacing the vessel "Enhydra" with a zero-emission capable hybrid vessel. • Operational Cost was derived by taking the average Excursion Vessel fuel consumption (gallon per hp per year) multiplied by the 30% zero-emission power requirement in the proposed regulation multiplied by the constant value of $0.07/hphr cost savings from diesel to electric. • Engine Capital Cost: CARB staff assumed the same Engine Capital Cost as the Repower to Tier 4 scenario, which was taken from the Cal Maritime Study. Average Engine Capital Cost of $301,000 (Table 32, page 69) divided by hp of 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines) to get $262/hp. • Labor and Installation Cost: CARB staff derived this value by taking a Total Vessel Cost of $1,910,00 divided by hp of 800 to get $2,388/hp, and subtracting the Engine Capital Cost of $262/hp to get a Labor and Installation Cost of $2,126/hp.

Table IV: Major Cost Inputs—Redundant Labor and Installation Costs for DPF Retrofit
CARB staff assume that engine repower and DPF retrofits will occur at the same time, and therefore some of the Labor and Installation (which the cost workbook applies separately to engine repower and DPF retrofit scenarios) are redundant. CARB staff assume the Engine Room Access and Haul Out/Shipyard Costs are redundant Labor and Installation Costs, and removed them from the final $/hp Labor and Installation Cost values.

Vessel Category	Unit Redundant Labor and Installation Costs ($/hp)	Basis
Ferry (Catamaran)	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Ferry (Monohull)	$46	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $46/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $30,000 (Table 45, page 80) • Haul Out/Shipyard Cost: $91,000 (Table 45, page 80) • hp: 2,000 (Table 37, page 71, 1,000 hp per main engine * 2 main engines)
Pilot Boat	$60	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $60/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $95,000 (Table 87, page 119) • Haul Out/Shipyard Cost: $102,000 (Table 87, page 119) • hp: 1,700 (Table 80, page 113, 850 hp per main engine * 2 main engines).
Push/Tow Tug	$46	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $46/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $65,000 (Table 70, page 103) • Haul Out/Shipyard Cost: $91,000 (Table 70, page 103) • hp: 2,000 (Table 62, page 95, 1,000 hp per main engine * 2 main engines)

Escort/Ship Assist Tug	$13	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $13/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $65,000 (Table 61, page 94) • Haul Out/Shipyard Cost: $91,000 (Table 61, page 94) • hp: 6,850 (Table 53, page 88, 3,425 hp per main engine * 2 main engines)
ATB Tug	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Research Vessel	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Commercial Passenger Fishing	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Excursion	$79	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $79/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $30,000 (Table 36, page 70) • Haul Out/Shipyard Cost: $91,000 (Table 36, page 70) • hp: 1,150 (Table 28, page 63, 575 hp per main engine * 2 main engines)
Dredge	$50	Value derived dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $50/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $65,000 (Table 21, page 50) • Haul Out/Shipyard Cost: $115,000 (Table 21, page 50)

		• hp: 2,314 (Table 15, page 40, total hp is sum of individual engines: 1500 hp, 350 hp, 191kw=256hp, and 155kw=208hp)
ATB Barge	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Bunker Barge	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Other Barge	$51	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking the average of Ferry (Monohull, $46/hp), Pilot Boat ($60/hp), Push/Tow Tug ($46/hp), Escort/Ship Assist Tug ($13/hp), Excursion ($79/hp), Dredge ($50/hp), Crew Supply ($53/hp), and Workboat ($60/hp) to get $51/hp.
Crew Supply	$53	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $53/hp. Values come from the Cal Maritime Study. • Engine Room Access Cost: $30,000 (Table 77, page 111) • Haul Out/Shipyard Cost: $91,000 (Table 77, page 111) • hp: 1,701 (Table 71, page 104, 567 hp per main engine * 3 main engines).
Workboat	$60	Value derived by dividing the sum of the Engine Room Access and Haul Out/Shipyard Costs by the total hp to get $60/hp. Values come from the Cal Maritime Study. The combined DPF Retrofit cost for Workboat and Special Use is used to represent the Workboat. • Engine Room Access Cost: $65,000 for Workboat (Table 94 page 126) and $65,000 for Special Use Table 103, page 133) to get $130,000. • Haul Out/Shipyard Cost: $91,000 for Workboat (Table 94 page 126) and $91,000 for Special Use Table 103, page 133) to get $182,000.

		• hp: 3,050 (Workboat: Table 89, page 121, 400 hp per main engine * 2 main engines. Special Use: Table 95, page 127, 750 hp per main engine * 2 main engines + Auxiliary Engine 750 hp).

Table V: Major Cost Inputs—Loss of Use

Vessel Category	Unit Cost ($/hp)	Basis
Ferry (Catamaran)	$87	The cost information was taken from "*EPA Tier 4 Feasibility for Existing Vessels*," Incat Crowther for Golden Gate Bridge, Highway and Transportation District, December 2019. • Loss of Use Cost: $780,000 • hp: 9,005
Ferry (Monohull)	$87	CARB staff assumes the Loss of Use Cost is the same as the Ferry (Catamaran).
Ferry (Short Run)	$87	CARB staff assumes the Loss of Use Cost is the same as the Ferry (Catamaran).
Pilot Boat	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Push/Tow Tug	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Escort/Ship Assist Tug	$47	The cost information comes from a Crowley Maritime comment letter to CARB dated April 29, 2020. • Loss of Use Cost: $320,000 • hp: 6,850
ATB Tug	$52	The cost information comes from a Crowley Maritime comment letter to CARB dated April 29, 2020. • Loss of Use Cost: $600,000 • hp: 11,532.5. The hp is an average of two types of ATB Tugs reported by Crowley that are used to represent this category: 10,926hp and 12,102hp.
Research Vessel	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.

Commercial Passenger Fishing	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp..
Excursion	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp..
Dredge	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
ATB Barge	$174	The cost information comes from a Crowley Maritime comment letter to CARB dated April 29, 2020. • Loss of Use Cost: $600,000 • hp: 3,441 The hp was reported by Crowley Maritime to CARB by way of the CARB CHC Reporting Database. CARB staff averaged both 650 and 550 barge vessel hp to get a value of 3441.
Bunker Barge	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Other Barge	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Crew Supply	$188	The cost information was provided by Tom Croft (C&C Boats, Inc.) in an email to Tracy Haynes (CARB) dated March 12, 2020: • Loss of Use Cost: $375,000 • hp: 1,996. The average hp from C&C Boats is used to represent the vessel.
Workboat	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Value derived by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels to get $110/hp.
Commercial Fishing	$110	Cost information was not provided by industry stakeholders or the Cal Maritime Study. Staff derived the $/hp by taking an average of the unit cost for Ferry (Catamaran), Escort/Ship Assist Tug, ATB Tug, ATB Barge, and Crew Supply vessels.

Table VI: Major Cost Inputs— Vessel Residual/Resale Value Before Replacement (Benefit)

Vessel Category	Unit Cost ($/hp)	Basis
Ferry (Catamaran)	$1,166	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Ferry (Monohull)	$1,000	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Pilot Boat	$1,151	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Push/Tow Tug	$1,334	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Escort/Ship Assist Tug	$876	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
ATB Tug	$2,236	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Research Vessel	$2,236	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Commercial Passenger Fishing	$1,108	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Excursion	$955	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Dredge	$2,939	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
ATB Barge	$8,219	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Bunker Barge	$2,236	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Other Barge	$2,236	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Crew Supply	$847	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.
Workboat	$2,361	CARB staff assume, on average, the vessel would have 40% of the replacement cost when disposed.

Table VII-A: Administrative Cost Inputs—Recordkeeping and Reporting, Vessel Labeling, Facility Report

Vessel Category	Recordkeeping and Reporting ($ Per Vessel Per Year)	Vessel Labeling Cost ($ Per Vessel)	Facility Report Cost ($ Per Vessel Per Year)	Vessel Numbers in 2023
Ferry	$200	$150	$100	73
Pilot Boat	$200	$150	$100	10
Push/Tow Tug	$200	$150	$100	158
Escort/Ship Assist Tug	$200	$150	$100	73
ATB Tug	$200	$150	$100	13

Vessel Category	Recordkeeping and Reporting ($ Per Vessel Per Year)	Vessel Labeling Cost ($ Per Vessel)	Facility Report Cost ($ Per Vessel Per Year)	Vessel Numbers in 2023
Research Vessel	$200	$150	$100	31
Commercial Passenger Fishing	$200	$150	$100	570
Excursion	$200	$150	$100	408
Dredge	$200	$150	$100	80
ATB Barge	$200	$150	$100	31
Bunker Barge	$200	$150	$100	51
Other Barge	$200	$150	$100	163
Crew Supply	$200	$150	$100	141
Workboat	$200	$150	$100	333

Basis

- CARB staff assume the recordkeeping and reporting would take 4 personnel hours to prepare, with a personnel hour cost of $50, resulting in $200 per vessel per year.
- CARB staff assume the vessel labeling would take 2 personnel hours, with a personal hour cost of $50, resulting in $100 per vessel per year, combined with a $50 materials cost, for a total of $150 per vessel.
- CARB staff assume the facilities reporting cost is half of the cost of the vessel Recordkeeping and Reporting Costs, resulting in $100 per vessel per year.
- See Table I “Engine and Vessel Population” for more information about the vessel population methodology.

Table VII-B: Administrative Cost Inputs—Opacity Testing

Vessel Category	Opacity Cost ($ Per Engine)	Number of Engines	Basis
Ferry	$200	264	The cost of an opacity test for a diesel truck is $65, based on a call CARB staff had with CA Diesel Compliance, Inc. on June 24, 2020. CARB staff assumes the opacity test cost of a CHC
Pilot Boat	$200	28	
Push/Tow Tug	$200	540	
Escort/Ship Assist Tug	$200	202	
ATB Tug	$200	66	
Research Vessel	$200	91	

Vessel Category	Opacity Cost ($ Per Engine)	Number of Engines	Basis
Commercial Passenger Fishing	$200	1,335	engine would be three times that of a diesel truck engine. See Table I "Engine and Vessel Population" for more information about the engine population methodology.
Excursion	$200	1,163	
Dredge	$200	213	
ATB Barge	$200	76	
Bunker Barge	$200	139	
Other Barge	$200	370	
Crew Supply	$200	403	
Workboat	$200	706	

Table VII-C: Administrative Cost Inputs—Costs for Implementation and Enforcement of Regulation

Position	Number of Positions	Total PY Cost Year 1	Total PY Cost Subsequent Years	Basis
Air Resources Engineer (Range D) - TTD	1	$246,960	$245,960	PY cost sheet provided by CARB's Administrative Services Division. Total PY cost includes 26% indirect labor cost.
Air Resources Technician II- TTD	2	$226,800	$224,800	
Air Pollution Specialist (Range C) - TTD	1	$234,360	$233,360	
Air Resources Supervisor - TTD	0.33	$94,920	$93,920	
Air Pollution Specialist (Range C) - Enforcement	3	$703,080	$700,080	
Air Resources Technician II - Enforcement	2	$226,800	$224,800	
Air Resources Supervisor- Enforcement	0.33	$94,920	$93,920	
Travel Cost	$61,290 annual Travel Costs based on CARB staff assumption that travel expenses would be needed to implement the regulation.			
Contracts	$50,000 annual Contracts cost based on CARB staff assumption that external entity would be contracted to assist with reporting vessel activity to CARB.			

Table VII-D: Administrative Cost Inputs— Financial Feasibility Report (Compliance Extensions)

Vessel Category	Cost per Vessel	Percentage of Vessels for Financial Review Report	Vessel Numbers in 2023
Ferry, Catamaran	$400	45%	39
Ferry, Monohull	$400	15%	18
Ferry, Short Run	$400	0%	16
Pilot Boat	$400	45%	10
Push/Tow Tug	$400	15%	158
Escort/Ship Assist Tug	$400	5%	73
ATB Tug	$400	5%	13
Research Vessel	$400	45%	31
Commercial Passenger Fishing	$400	65%	570
Excursion	$400	5%	408
Dredge	$400	15%	80
ATB Barge	$400	5%	31
Bunker Barge	$400	5%	51
Other Barge	$400	15%	163
Crew Supply	$400	45%	141
Workboat	$400	45%	333

Basis

- CARB staff assume it will take 8 personnel hours to prepare each Financial Feasibility Report. At $50 per personnel hour, this results in a total of $400 per report.
- The total percentage of vessels in each category that incur the Financial Feasibility Report expense is based on the percentage of vessels that receive a compliance extension by their initial compliance date. See Table I-E for more information about compliance scenario assumptions.
    - CARB staff assume 50% of these vessels would need to file one report as part of the compliance extension application, and 50% would need to file two reports as part of two compliance extension requests.
- See Table I “Engine and Vessel Population” for more information about the vessel population methodology.

Table VII-E: Administrative Cost Inputs—Naval Architect Report (Compliance Extensions)

Vessel Category	Cost ($ per report)	Percentage of Vessels for Naval Architect Report	Vessel Numbers in 2023
Ferry, Catamaran	$40,620	45%	40
Ferry, Monohull	$40,620	15%	20
Ferry, Short Run	$40,620	0%	13
Pilot Boat	$40,620	45%	10
Push/Tow Tug	$40,620	15%	158
Escort/Ship Assist Tug	$40,620	5%	73
ATB Tug	$40,620	5%	13
Research Vessel	$40,620	45%	31
Commercial Passenger Fishing	$40,620	65%	570
Excursion	$40,620	5%	408
Dredge	$40,620	15%	80
ATB Barge	$40,620	5%	31
Bunker Barge	$40,620	5%	51
Other Barge	$40,620	15%	163
Crew Supply	$40,620	45%	141
Workboat	$40,620	45%	333

Basis

- CARB staff averaged per vessel costs from three sources of Naval Architect Costs:
  - WETA provided $1.05 million Naval Architect cost for its fleet of 17 vessels, which averages $61,764 per vessel.
  - Based on results from a 2019 CARB survey of CHC owners/operators, the average Naval Architect Report cost is $27,250 per vessel.
  - Golden Gate Bridge provided a cost of $230,000 for 7 vessels, which averages to $32,860 per vessel.
- The total percentage of vessels in each category that incur the Naval Architect Report expense is based on the percentage of vessels that receive a compliance extension by their initial compliance date. See Table I-E for more information about compliance scenario assumptions.
  - CARB staff assume 50% of these vessels would need to file one report as part of the compliance extension application, and 50% would need to file two reports.
- See Table I “Engine and Vessel Population” for more information about the vessel population methodology.

Table VIII-A: Infrastructure Cost Inputs—Dock Power Infrastructure

Dock Power Infrastructure, Maintenance and Labor Costs	Unit Cost ($/hp)	Basis
Upstream Utility Cost	$0	Value defined as the cost to bring power to the charging station. Value of is $0 based on CARB staff assumption that there is sufficient power available at the site.
Charging Station Cost	$227	Value derived by dividing line item cost of $278,400 by hp of 1,228.50. These values were taken from a 2014 San Diego Air Pollution Control District (SDAPCD) Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program.
Installation Cost	$30	Value derived by dividing line item cost of $37,060 by hp of 1,228.50. These values were taken from a 2014 San Diego Air Pollution Control District (SDAPCD) Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program.
Charging Equipment Cost	$62	Value derived by dividing line item cost of $76,095 by hp of 1,228.50. These values were taken from a 2014 San Diego Air Pollution Control District (SDAPCD) Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program.
Dock Construction Cost	$0	Value is the cost to construct the dock for the charging. Because these vessels are already operating and have existing docks, and there is no evidence suggesting new docks will need to be constructed to convert existing ferry operations, CARB staff assume this cost is $0.
Total Project Cost	$319	Value is the sum of the following costs ($/hp): Upstream Utility Cost, Charging Station Cost, Installation Cost, Charging Equipment Cost, and Dock Construction Cost. These values were taken from a 2014 San Diego Air Pollution Control District (SDAPCD) Pacific Tug Shorepower project (Project Number CMF11/12.2-209), funded by the Carl Moyer Program.

Dock Power Infrastructure, Maintenance and Labor Costs	Unit Cost ($/hp)	Basis
Percentage of Vessels Without Dock Power Capability	24%	Percentage is based on a 2019 CARB survey of CHC owners/operators.
Percent of Vessels Without Dock Power Capability who would Use Dock Power	12%	CARB staff estimate that of the percentage of vessels without dock power capability, half will comply using dock power. CARB staff assume that the other half will not exceed auxiliary engine idling limits in the proposed regulation, and therefore will be in compliance.
Total Aux Engine hp	356,221	CARB staff took the total auxiliary hp of all the engines in the engine inventory, except for the "Commercial Fishing" vessel category. See Table I "Engine and Vessel Population" for more information about the engine population methodology.
CRF (5%, 20 years) for Infrastructure	0.08	The 20-year berth equipment useful life is based on claimed confidential data obtained from two OGV industry sources that requested non-attribution. The sources indicated equipment life for shore power at OGV berths ranging from 15 to 20 years. CARB staff assumes a similar equipment life would apply to properly maintained dock power infrastructure for commercial harbor craft.

Table VIII-B: Infrastructure Cost Inputs— Short Run Ferry and Excursion Charging Infrastructure

Cost Item	Cost	Basis
Upstream Utility Cost	$0	Value defined as the cost to bring power to the charging station. Value of is $0 based on CARB staff assumption that there is sufficient power available at the site.
Charging Station Cost	$3,341,753	Cost Information provided by WETA to CARB staff during a conference call on July 23, 2020. WETA provided a total Short Run infrastructure cost of $4.7 million; CARB staff took the split of the Charging Station Cost, Installation Cost, and Charging Equipment Cost for Dock Power and applied it to this value to get this cost.

Cost Item	Cost	Basis
Installation Cost	$444,847	Cost Information provided by WETA to CARB taff during a conference call on July 23, 2020. WETA provided a total Short Run infrastructure cost of $4.7 million; CARB staff took the split of the Charging Station Cost, Installation Cost, and Charging Equipment Cost for Dock Power and applied it to this value to get this cost.
Charging Equipment Cost	$913,400	Cost Information provided by WETA to CARB staff during a conference call on July 23, 2020. WETA provided a total Short Run infrastructure cost of $4.7 million; CARB staff took the split of the Charging Station Cost, Installation Cost, and Charging Equipment Cost for Dock Power and applied it to this value to get this cost.
Dock Construction Cost	$0	Value is the cost to construct the dock for the charging. Because these vessels are already operating and have existing docks, and there is no evidence suggesting new docks will need to be constructed to convert existing ferry operations, CARB staff assume this cost is $0.
Number of Facilities, Short Run Ferry	8	There are 16 Short Run ferries in the State. CARB staff assume 8 charging facilities are needed to charge these ferries.
Number of Facilities, Excursion	11	CARB staff derived the number of Excursion Vessel facilities by dividing 13,531 hp, which is the sum of the Excursion Vessel replacement hp from 2023 to 2037, by 912, which is the average Excursion Vessel hp calculated from the engine inventory. See Table I “Engine and Vessel Population” for more information about the engine population methodology.
Total Number of Facilities	19	The sum of the Short Run Ferry and Excursion Vessel facilities.
CRF (5%, 20 years) for Infrastructure	0.08	The 20-year berth equipment useful life is based on claimed confidential data obtained from two OGV industry sources that requested non-attribution. The sources indicated equipment life for shore power at OGV berths ranging from 15 to 20 years. CARB staff assumes a similar equipment life would apply to

Cost Item	Cost	Basis
		properly maintained dock power infrastructure for commercial harbor craft.
Excursion, Average hp	912	CARB staff took the average hp of the Excursion engines in the engine inventory. See Table I “Engine and Vessel Population” for more information about the engine population methodology.
Excursion, Total Vessel Replacement hp	10,123	CARB staff added the total Excursion Vessel replacement hp from 2023 to 2037.