State of California
AIR RESOURCES BOARD

Proposed Control Measure for Ocean-Going Vessels At Berth

Standardized Regulatory Impact Assessment (SRIA)

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Note to Reader

This document describes the need for and requirements of the Control Measure for Ocean-Going Vessels At Berth (Proposed Regulation). It also presents CARB staff's analysis of the benefits, costs, and fiscal and macroeconomic impacts associated with that proposal, as well as two alternatives.

For those interested in the costs and fiscal impacts, the body of this report provides the results of the quantitative analyses. For those who wish a deep understanding of the cost inputs, assumptions, calculations and outputs, staff suggests that you:

1. Begin with Appendix C, which identifies which control technology we assumed would be used at each affected berth.

2. Review Appendix E, which provides the equations we used to calculate costs.

3. Consult Appendix A that identifies all of the inputs for the cost for purchase, installation, maintenance, labor, reporting, permitting, and other expenses that we assume would be incurred by private and public entities in response to the Proposed Regulation.

4. The Cost Analysis Workbook, Appendix B, calculates cost estimates for the Proposed Regulation. The cost workbook is also available electronically on our program website at: https://ww3.arb.ca.gov/ports/shorepower/shorepower.htm

The chapters in the main document then summarize staff's conclusions on the total costs by affected party and year.

A. INTRODUCTION

1. Primer on Vessels, Operations, and Industry Structure

The Proposed Regulation would affect multiple private and public entities operating across California, in an industry that uses many different structures to serve its customers. This section is designed to aid the reviewer who is not familiar with the marine industry and vessel operations at berth. The objective is to provide an understanding of the most common terms and procedures referenced in staff's analyses by introducing a number of basic facts and relationships. These abbreviated explanations are not intended to define or interpret specific terms for purposes of the Proposed Regulation, nor do they represent every scenario in place in California.

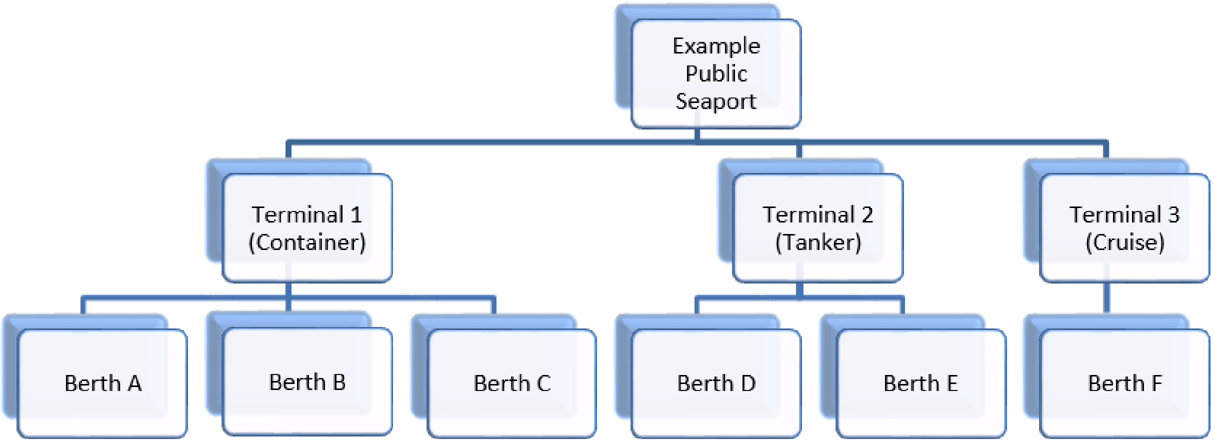
a. Basics on Ports and Terminals

In the context of this document and the Proposed Regulation, ocean-going vessels are ships that stop at, or "visit," affected California ports or independent marine terminals during their voyage.

i. **Seaports and Included Port Terminals**

Ports are semi-autonomous local public entities operating under the jurisdiction of the California State Lands Commission (CSLC), which oversees the State's public tidelands. Each port can have one to several terminals and each terminal can have one or many berths. Terminals are facilities consisting of wharves, piers, docks and other berthing locations and adjacent storage, which are used primarily for loading and unloading of passengers, cargo, or material from vessels or for the temporary storage of this cargo or material on-site. Figure 1A below shows a simple representation of a public seaport providing services for container, tanker, and cruise vessels.

Figure A1: Description of the Relationship Between the Port, Terminal and Berth at a Typical Public Landlord Port



There are two primary types of public seaports. The largest typically use the "landlord port"[1,2] model that provides long-term leases or rental of entire terminals to private companies referred to as "terminal operators"; those terminal operators then offer services to the vessel fleets and cargo owners using that terminal. In the world of international cargo, there is a complex and frequently shifting web of alliances between different vessel fleets (also known as ocean carriers) that may have cooperative agreements to share space on vessels to maximize efficiency, and between individual vessel fleets or fleet alliances and terminal operators for services. California's smaller ports use an "operational port" model; they also act as the terminal operator and directly serve vessel fleets.[3]

A port may also employ a combination of these models. For example, in Figure A1, the container terminal (Terminal 1) may be leased to a private company that contracts with specific vessel fleets, while the tanker and cruise terminals (Terminals 2 and 3) may be operated by the port directly and accept visits by a wider range of vessel fleets.

Public seaports typically have substantial wharf or dock structures on or attached to the terminal land, with electrical connections. Pollution control equipment to reduce vessel emissions at berth can usually be installed on these wharves.

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[1] Port of Los Angeles, Port 101, https://www.portoflosangeles.org/about/port-101 (last accessed July 2019)

[2] Port of Long Beach, FAQs - Does the Port receive funding from the City of Long Beach?, http://www.polb.com/about/faqs.asp#530 (last accessed July 2019)

[3] Janice Hoppe-Spiers, Transportation and Logistics International, Port of Stockton, http://www.tlimagazine.com/sections/shipping-and-ports/2359-port-of-stockton

ii. **Independent Marine Terminals**

In Northern California, there are also independent marine terminals that are located and operate separate from any port. Most of these are marine oil terminals owned and operated by oil companies with nearby refining operations. The physical structure at these oil terminals is markedly different than a typical port. Vessels dock at long wharves that may extend hundreds of feet into the waters in and around the San Francisco Bay; these are insubstantial structures with limited electrical power capacity. Many of these wharves cannot accommodate pollution control equipment without extensive construction (on land and in the water) to support additional weight and demand for power.

b. Basics on Vessel Types

The following types of vessels would have emissions reduction requirements at berth under the Proposed Regulation.

i. **Container**

These vessels are designed to carry cargo stored in standardized ocean shipping containers.[4] Vessel size is classified by how many twenty-foot-equivalent units (TEUs) can be carried onboard. A typical container is 40 feet long, or two TEUs.

ii. **Reefer**

These refrigerated or “reefer” vessels are typically used to carry perishable commodities that require temperature-controlled transportation. The products may be in containers or in bulk form.[5] The vessel must provide substantial electrical power to support product refrigeration throughout the voyage.

iii. **Cruise**

These passenger or “cruise” vessels are used to carry people for recreational voyages.[6]

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[4] 17 CCR § 93118.3. (c)(8), Definitions, Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port, page 3, https://ww3.arb.ca.gov/regact/2007/shorepwr07/93118-t17.pdf.

[5] 17 CCR § 93118.3. (c)(28), Definitions, Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port, page 6, https://ww3.arb.ca.gov/regact/2007/shorepwr07/93118-t17.pdf.

[6] 17 CCR § 93118.3. (c)(25), Definitions, Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port, page 6, https://ww3.arb.ca.gov/regact/2007/shorepwr07/93118-t17.pdf.

iv. Roll-On-Roll Off (or "Ro-Ro")

These vessels haul wheeled cargo which "roll-on and roll-off" the vessel via a built-in ramp. Ro-ro vessels may carry exclusively automobiles and/or a mixture of mobile equipment.[7] For this document, this category includes automobile and ro-ro vessel types.

v. Tankers

These vessels are designed to carry liquid or gaseous products. There are many different types of tankers that specialize in the transport of various products including: crude oil, liquefied natural gas (LNG), and chemicals like fertilizers or fuel additives.[8] There are two ways to power the loading and off-loading of cargo on tankers, boiler powered steam pumps (typically used to off-load crude oil from crude tankers) and auxiliary engine powered electric pumps (typically used to off-load refined petroleum products, chemicals, or non-crude oils).

vi. Bulk and General

There are also bulk and general cargo vessels that visit California ports, but the Proposed Regulation would not impose requirements to control emissions at berth on those vessel types.[9] Bulk and general cargo vessels account for the lowest source of emissions due to the generally low power requirements on-board these types of vessels while at berth. In addition, bulk and general cargo vessels typically carry low value cargo (aggregates, dry grains, lumber). These materials could be easily carried by truck or rail as an alternative, which would increase emissions versus transporting on-board a vessel. Bulk and general cargo vessels also face operational challenges at berth as a result of their cargo loading/off-loading activity, which is referred to as "line-hauling. While line-hauling, the vessel moves along the wharf as it unloads, which makes connecting to shore power or a capture and control system very difficult because the connection would have to be interrupted every time the vessel changes position.

c. Basics on Vessel Operations and Procedures

This section seeks to describe only those maritime operations that are directly relevant to the Proposed Regulation and its potential impacts.

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[7] Wallenius Wilhelmsen, Frequently Asked Questions - What is the meaning of RoRo?, https://www.2wglobal.com/online-tools/frequently-asked-questions/what-is-the-meaning-of-roro/.

[8] Marine Insight, What are Tanker Ships? (June 11, 2019), https://www.marineinsight.com/types-of-ships/what-are-tanker-ships/.

[9] Shipping Guides, LTD, Vessel Types Explained, https://www.portinfo.co.uk/portinformation/ourmaritimeblog/vessel-types-explained.

i. **In Transit**

When a vessel is underway (or “in transit”), the main engines provide power for propulsion, while the auxiliary engines power the onboard electrical systems for navigation and communication, climate control, and lights. The ship’s boilers provide heat to: keep the very viscous bunker fuel used in the main engines in liquid form, heat the interior of the vessel for crew comfort, and provide hot water onboard. On oil tankers, boilers also serve a safety function for flammable liquids and generate steam to power the pumps that move product to and from shore.

ii. **At Anchor**

A vessel approaching a port or marine terminal may stop “at anchor” a short distance offshore while waiting for a berth or labor to become available.

iii. **Maneuvering**

When a vessel is ready to enter the immediate area of the port or terminal, a local pilot typically boards and assumes navigation control, while tugboats push or pull the vessel to maneuver it into position at the assigned berth. In the San Francisco Bay Area, pilots board the vessels further out at sea, beyond the Golden Gate Bridge, for safety purposes.

iv. **At Berth**

A vessel may be berthed in a “port” or “starboard” orientation, which can affect the ability of the vessel to connect with an emission control system. Staff understands that the decision about which orientation to use rests in the hands of the pilot, the vessel master, and the terminal operator, based on the factors such as physical structure of the channel and wharf, the presence of vessels at adjacent berths, and the tides. This decision can impact the ability of a vessel to successfully connect to an emission control system, depending on the vessel and berth configurations.

When the vessel is docked at berth, the main engines are shut down and large lines are used to secure the vessel to the wharf or dock to keep it in place. This step is called securing the vessel. Then the gangway of the ship is lowered, a net is put in place for safety purposes, and U.S. Customs and Border Protection inspectors board the vessel. These inspectors must clear the vessel before anyone else can board or disembark, and before a cargo vessel can be worked by labor. Delays during this procedure therefore delay the ability to connect the vessel to any emission controls not solely on the vessel.

The auxiliary engines and boilers continue to operate while a typical vessel is at berth to provide onboard electrical power, steam and other operations. Once a vessel is “ready to work,” the chosen emission control system can be connected to the vessel.

d. Basics on Air Pollution from Vessels at Berth

As noted, vessels at berth typically operate both auxiliary engines and boilers. Vessel auxiliary engines are typically diesel-powered. At berth and near shore, these engines are required by international, federal, and State requirements to burn distillate fuel (marine gas oil or marine diesel oil), a cleaner, lower sulfur version of diesel fuel (relative to the heavy bunker fuel used in the main engines). The California Air Resources Board (CARB) has a separate regulation that covers fuel used in vessel main engines, auxiliary engines, and boilers.

Air pollutants generated from combustion of diesel or distillate fuel in these auxiliary engines include: toxic diesel particulate matter (DPM) (CARB formally identified exhaust from diesel-fueled engines as an air toxic in 1998), as well as fine particulate matter (PM2.5), nitrogen oxides (NOx), reactive organic gases (ROG), greenhouse gases (GHG), and the short-lived climate pollutant black carbon. Black carbon is an element (and subset) of both DPM and PM2.5. DPM is a constituent (and subset) of PM2.5 for diesel engines.

Vessel boilers also use diesel or distillate but to directly fuel a flame to create heat. Boiler exhaust includes other compounds that CARB has identified as air toxics (like formaldehyde, benzene, and arsenic), but the particulate matter exhaust is not considered DPM because no engine exhaust is involved. As a result, the requirements for control of emissions from tanker boilers in the Proposed Regulation would achieve PM2.5 reductions, but not DPM reductions. Like auxiliary engines, boilers also emit NOx, ROG, GHG, and other air pollutants.[10]

e. Basics on Options to Reduce Vessel Emissions at Berth

The Proposed Regulation would establish a performance-based emissions standard to reduce vessel emissions from auxiliary engines at berth on all covered vessel types, and from boilers powering steam-driven pumps used to off-load cargo on tanker vessels. Today, three approaches exist to achieve the performance standard: shore power, barge-based emissions capture and control, and land-based emissions capture and control.

i. **Shore Power**

Under this approach, once a vessel is at berth and ready to be worked, the vessel's electrical system is connected to shore-based electrical power and the auxiliary engines on-board the vessel are shut down for the duration of that connection.[11] The U.S. Navy pioneered this system decades ago, and a subset of commercial vessels visiting

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[10] California Air Resources Board, DRAFT: 2018/2019 Update to Inventory for Ocean-Going Vessels: Methodology and Results, (January, 2019), https://www.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf.

[11] California Air Resources Board, DRAFT TECHNOLOGY ASSESSMENT: OCEAN-GOING VESSELS (May 2018), Shore-side Electrical Power (Shore Power), page 68, https://ww3.arb.ca.gov/msprog/tech/techreport/ogv_tech_report.pdf.

California have been using it since about 2010 under environmental mitigation requirements and CARB's Existing Regulation. Vessels require a range of electrical power when connected. For example, a container vessel may draw 1 megawatt (MW) of electricity to replace its auxiliary engine operation at berth, while a large cruise vessel may draw 5 MW or more.

Current shore power applications use grid-based electrical power. State law requires increasing use of renewable power sources over time, resulting in a progressively cleaner, lower carbon grid. All CARB emission estimates for the Proposed Regulation account for the GHG emissions generated to produce grid power.

Shore power is the gold standard in air pollution control because it eliminates all on-site emissions (of all auxiliary engine pollutants) from a vessel at berth, rather than controlling a portion of those emissions. It also offers the opportunity to significantly reduce GHG because the California grid has a lower carbon footprint than burning liquid fuel onboard the vessel. However, it requires installation of electrical infrastructure both on the vessel and at the berth, as well as union labor to connect and disconnect the two.

Under CARB's Existing Regulation, the use of shore power is referred to as the "Reduced On-board Power Generation" option for compliance because the auxiliary engines on-board the vessel generate less power at berth. [12]

Shore power cannot be used in place of boiler operations because boilers are not electrical systems. However, electrically-driven, on-shore pumps can be used to augment or replace boiler operations on tankers to move liquid product to or from a vessel.

Staff expects shore power to be the compliance option of choice at container, reefer, and cruise terminals under the Proposed Regulation. Since most vessels fleets have already invested in the vessel-side infrastructure to comply with the Existing Regulation (as described in A.2.a.), the more they can connect (and save fuel that would otherwise be burned by running the auxiliary engines), the better the return on their investment. Ro-ros and tankers could use shore power, but numerous vessel operators and industry representatives for these vessel types have stated during public workshops and meetings with CARB staff that shore-side capture and control systems are more attractive than vessel side investments, because there are far fewer vessels that make regular or frequent calls to California (compared to container, reefer and cruise vessels on regular or "liner" routes).[13]

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[12] 17 CCR § 93118.3. (d)(1), Reduced Onboard Power Generation Option, Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port, page 8, https://ww3.arb.ca.gov/regact/2007/shorepwr07/93118-t17.pdf.

[13] Phone conversation with World Shipping Council on May 23, 2018; Industry comments during CARB At Berth Public Workshop on May 16, 2019.

ii. Barge-based Emissions Capture and Control Systems

This approach involves a system on a movable barge to capture and control emissions from the auxiliary engines and boilers, which continue to operate for the full period at berth. Once a vessel is at berth and ready to be worked, a tug moves the barge alongside the vessel and a small crane[14] on the barge lifts a duct up and connects it to the top of the vessel's exhaust stack to "capture" the emissions. Then a small engine on the barge creates a vacuum to pull the vessel exhaust through the duct and route it down to pollution "control" technology on the barge. The control element of the system is very similar to control technology in place for many years at stationary sources of air pollution.[15]

This compliance option captures emissions from both auxiliary engines and boilers at berth. It reduces emissions of DPM, PM2.5, NOx, ROG, and black carbon. It can result in a slight increase in GHG emissions if a combustion engine is used on the barge to power the system for those visits. Overall, the Proposed Regulation will result in decreased GHG emissions since reductions from shore power will more than offset any small increases from capture and control systems. Advancements are being made in battery and fuel cell technology to power ferries in California and Northern Europe indicate that future versions of generators powering barge-based capture and control systems could be adapted to be zero-emission on-site utilizing these new technologies. [16,17]

These systems are dispatched to reduce emissions from specific vessels based on contracts between vessel fleets and the third-party technology providers. They offer the opportunity to reduce emissions from vessels not equipped for shore power and to back up shore power systems in case of breakdown. The third-party system provider typically has its own staff on the barge to support this operation.

Thus far, CARB staff has issued Executive Orders formally approving two barge-based system designs (by two manufacturers), consistent with the provisions of the Existing

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[14] In the SRIA, the terms "crane" and "positioning boom" are used generically to represent equipment used to lift and position the capture and control system ducting over the vessel emission stack in order to collect the exhaust. These terms do not represent labor classifications or categories, unless specifically noted.

[15] Bill Mongelluzzo, California OKs new emissions control technology for maritime use (July 01, 2015), JOC.com, https://www.joc.com/port-news/us-ports/california-oks-new-emissions-control-technology-maritime-use_20150701.html.

[16] GreenBiz, The future of ferries is electric, too (June 2019), https://www.greenbiz.com/article/future-ferries-electric-too.

[17] ARS Technica, Group to fund and operate first hydrogen fuel ferry fleet in the US (June 2019), https://arstechnica.com/information-technology/2019/06/group-to-fund-and-operate-first-hydrogen-fuel-ferry-fleet-in-the-us/.

Regulation.[18,19] Approval required "real world" demonstration of the effectiveness of each system in both capturing and controlling emissions on a number of vessels at berth. The calculated performance of the system must consider the emissions from the small engine on the barge. Each system has continuous emissions monitoring to detect any problems with performance over time. These are referred to as the "Equivalent Emissions Reduction" option for compliance with the Existing Regulation.[20]

Terminals with wider channels may readily accommodate a barge alongside a vessel at berth, but terminals with narrow channels may not be able to physically fit a barge without blocking navigation in the channel. At Northern California's independent marine terminals, there are also potential constraints resulting from the impacts of tidal flows and from prohibitions on impeding the transit of other vessels in designated shipping lanes (between the supports of an adjacent bridge, for example).

CARB staff expects the barge-based capture and control systems to be used to augment shore power capability at container terminals, and as an option at ro-ro terminals under the Proposed Regulation. Some ports are also pursuing development of barge-based systems to capture emissions at berth from the bulk and general cargo vessel fleets that would not be captured by the Proposed Regulation. This use could achieve additional emission reductions to meet environmental mitigation obligations for new port projects or to augment strategies for attainment of air quality standards.

iii. Land-based Emissions Capture and Control Systems

This approach is essentially a land-based version of the barge-based system described above. There is one prototype unit in operation that is semi-mobile (the system can be moved along the dock with a heavy truck). Once the unit is in place on the dock, the system's articulated arm raises and places the ducting over the vessel stack. The system captures and routes the vessel exhaust emissions from auxiliary engines and boilers to the landside control technology.[21]

Like the barge-based system, this compliance option would capture emissions from both auxiliary engines and boilers at berth. It reduces emissions of DPM, PM2.5, NOx, ROG, and black carbon. However, it can result in a slight increase in GHG emissions if a combustion engine is used to power the system. Overall, the Proposed Regulation will result in decreased GHG emissions since reductions from shore power will more than offset any small increases from capture and control systems. Future versions

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[18] California Air Resources Board, Executive Order AB-15-01 (June 25, 2015), https://ww3.arb.ca.gov/ports/shorepower/eo/ab-15-01.pdf.

[19] California Air Resources Board, Executive Order AB-15-02 (October 17, 2015), https://ww3.arb.ca.gov/ports/shorepower/eo/ab-15-02.pdf.

[20] 17 CCR § 93118.3. (d)(2), Equivalent Emissions Reduction Option, Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port, page 12, https://ww3.arb.ca.gov/regact/2007/shorepwr07/93118-t17.pdf.

[21] California Air Resources Board, DRAFT TECHNOLOGY ASSESSMENT: OCEAN-GOING VESSELS (May 2018), page 70, https://ww3.arb.ca.gov/msprog/tech/techreport/ogv_tech_report.pdf.

could be zero-emission on-site, powered by grid electricity, or by using batteries or fuel cells as discussed with barge-based capture and control systems.

The existing system is serving vessels visiting one terminal, based on a contract between the third-party technology provider and the terminal operator. Such systems offer the opportunity to reduce emissions from vessels not equipped for shore power. The third-party system provider typically has its own staff present at the terminal to operate the positioning boom and support this operation.

CARB staff expects this type of land-based capture and control system to be the compliance option of choice for oil tankers under the Proposed Regulation. For that application, a single control system may have multiple arms and ducts to serve multiple berths at a terminal. As noted above in the discussion of independent marine terminals, installing a land-based system may require extensive shoring up of wharves to support the weight, and other infrastructure improvements.

iv. **Other Options**

To accommodate future innovations, the Proposed Regulation would provide extensive flexibility to develop and gain CARB staff approval of additional compliance approaches for systems on the vessel or on the land-side that are demonstrated to meet the emissions performance standard.

f. Basics on Who Is Responsible for Actions to Reduce Emissions At Berth

The Existing Regulation places nearly all the responsibility for compliance on the vessel fleets. However, even when those fleets invest in approved technology and take the appropriate actions, they cannot succeed alone. The terminal operators (directly and through their association contract with the labor unions) and port authorities also have critical roles to play. If any one of those parties fails, reducing emissions can be difficult or impossible.

That lesson drives the requirements in the Proposed Regulation to place appropriate responsibilities for compliance on all parties, which are necessary for achieving the required emissions reductions.

To follow staff’s cost analyses, it is helpful to highlight the most common practices today, who does what, and how the Proposed Regulation may affect those practices.

- Beneficial cargo owners: Hire shipping lines to carry cargo from one point to another. The beneficial cargo owner is responsible for the cargo being carried by the vessel. Depending on vessel type and the arrangement with the shipping line, the beneficial cargo owner may or may not control the vessel’s destination.

- Vessel fleets/fleet owners and operators: Own and/or operate vessels that carry cargo for beneficial cargo owners, or passengers on cruise ship. Vessel owners and/or operators are responsible for making sure their vessels comply with local, federal, and international regulation, such as California's vessel regulations. Vessel owners and/or operators are typically responsible for installing any shore power equipment on vessels.

- Terminal operators/operating ports: A facility that operates berths where ocean-going vessels call. Terminal operators act as a medium between ocean-going vessels and beneficial cargo owners to facilitate the movement of cargo from ocean-going vessels to trucks and rail for transport to inland destinations.

- Union labor at port terminals: Dock workers are responsible for loading and off-loading cargoes on ocean-going vessels in California. Union labor has the responsibility to connect vessels to shore power at ports and terminals; the extent of union labor's involvement in the process of connecting a vessel to an emissions control technology varies on port policies and the control technology.

- Port authorities: Entities responsible for the management of waterfront property, including managing, leasing, and constructing of berths and terminals. Port authorities are often responsible for installing shore power berths, as it involves changes to port infrastructure.

- Capture and control strategy operators: Refers to operators of emissions control strategies other than shore power, such as barge- and land-based capture and control systems. Vessels, terminals, ports, and third parties may all be potential operators of an alternative emissions control strategies at berth, depending on the location of the emissions control technology and the service contract agreed upon between the manufacturer of the technology and the party operating it. All operating parties have the responsibility to ensure that the emissions control strategy being used is CARB approved and follows all requirements in the Proposed Regulation.

For many of the investments that would be used to comply with the Proposed Regulation, there are multiple feasible scenarios regarding which party or parties would bear the initial cost and how that cost would be passed through to others as described in Table A1. For example:

- For all vessels carrying cargo, staff expects that costs incurred by ports, terminals, and vessel fleets could be passed through to the beneficial cargo owner and, ultimately, to the consumer in California or elsewhere.

- For cruise vessels, staff expects that costs incurred by ports, terminals, and vessel fleets could be passed through to passengers in California or elsewhere.

Table A1: Which Party Likely to Act to Reduce Emissions At Berth

Key Actions	Which Party Would Be Likely to Act? Which Party Would Likely Bear the Cost?
Retrofit vessels to accept shore power	Vessel fleet owners/operators would likely act and invest to equip their vessels, with the ability to pass the cost through to beneficial cargo owners in their rate structures.
Design, permit, and install shore power infrastructure at terminals	Ports and terminals may share responsibility to implement these projects, depending on the terms of each lease agreement; this analysis assumes ports would bear the initial cost and recoup it from terminal operators and terminal operators could pass the cost through to vessel fleets and beneficial cargo owners in their rate structures.
Maintain and repair shore power infrastructure at terminals	Ports and terminals are likely to identify individual responsibilities in their lease agreements; this analysis assumes ports would bear the initial cost and recoup it from terminal operators and terminal operators could pass the cost through to vessel fleets and beneficial cargo owners in their rate structures.
Operate shore power infrastructure at terminals	This analysis assumes that labor to operate shore power infrastructure at port-based terminals would be provided by the terminal operators, except at the Port of Los Angeles (POLA), where labor would be provided by the port.
Design, permit, and install a land-based emission capture and control system at a port-based terminal	At port-based terminals, ports and terminals may share responsibility to implement these projects, depending on the terms of each lease agreement; this analysis assumes that terminal operators would bear the initial cost for the emission control system and the ports would bear the cost for the infrastructure such as structural improvements. The ports and terminals could pass the cost through to vessel fleets and beneficial cargo owners in their rate structures.
Design, permit, and install land-based emission capture and control system at a marine terminal	At marine terminals, the terminal operators would be responsible for implementing these projects. This analysis assumes that terminal operators would bear the initial cost for the emission control system and would pass the cost through to vessel fleets and beneficial cargo owners in their rate structures. The costs in the SRIA reflect the initial cost only.
Maintain and repair land-based emission capture and control system at a port-based terminal	Ports and terminals are likely to identify individual responsibilities in their lease agreements; this analysis assumes that at all ports, except the Port of Long Beach (POLB), ports would bear the initial cost and recoup it from terminal operators, and terminal operators would pass the cost through to vessel fleets and beneficial cargo owners in their rate structures. This analysis assumes that terminal operators would bear the initial cost for maintaining systems at POLB.

Maintain and repair land-based emission capture and control system at a marine terminal	This analysis assumes that terminal operators would bear the initial cost for maintaining systems at marine terminals, and pass the cost through to vessel fleets and beneficial cargo owners in their rate structures.
Operate land-based emission capture and control system at a port-based terminal	This analysis assumes that labor to operate land-based capture and control systems at port-based terminals would be provided by the terminal operators, except at POLA where labor would be provided by the port.
Operate land-based emission capture and control system at a marine terminal	This analysis assumes that labor to operate land-based capture and control systems at marine terminals would be provided by the terminal operators.
Conduct performance testing of land-based emission capture and control systems at all terminals	Performance testing of the emission control systems would be required to retain CARB approval, and would be the responsibility of the party that owns the system, which this analysis assumes would be the terminal operators at both port-based and marine terminals, except at the Port of Hueneme.
Maintain and repair barge-based emission capture and control system	Third-party technology manufacturers are responsible if they retain ownership of the system (rather than selling it) and wish to continue contracting for services. This analysis assumes the vessel operators will incur these costs through the hourly charge.
Secure CARB approval of new alternative control system designs	Third-party technology developers are responsible for all actions and costs to prepare approvable test plans, conduct emissions testing on field units, report data, address issue, gain a CARB Executive Order, and pay any required fees to CARB for the technology review and approval. This analysis assumes that these costs will be passed through to the vessel operators through the hourly charge. If a vessel fleet develops an onboard system to reduce emissions to meet the performance standard, then that company would take on all responsibility for CARB approval of the alternative control technology. Although we have not assumed this to be the compliance pathway in this analysis.

2. Regulatory History

a. Existing Regulation

In December 2007, CARB approved the *Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port* Regulation (Existing Regulation).[22] The purpose of the Existing Regulation is to reduce emissions from diesel auxiliary engines on container vessels, reefer vessels, and passenger cruise vessels, while berthing at a California port. At berth, auxiliary engines are used by vessels to run power for lighting, ventilation, pumps, communication, heating, and other onboard equipment while a vessel is docked. Under the Existing Regulation, container, reefer, and cruise vessel fleets that visit specified California ports, as described below, are the regulated parties.

Container or reefer vessels that make 25 visits or more per calendar year to a regulated port and cruise vessels that make 5 or more visits per year to a regulated port are subject to the requirements of the Existing Regulation. Smaller vessel fleets (i.e., fleets that are comprised of container and reefer vessels that make fewer than 25 visits or cruise with fewer than 5 visits) and vessels that do not often frequent California ports are exempt from the Existing Regulation. The California ports included in the Existing Regulation are POLA, POLB, Oakland, Richmond, San Diego, San Francisco, and Hueneme.

- The Existing Regulation provides fleet operators two different pathway options to comply: the Reduced On-board Power Generation (ROPG or Shore Power) option, or the Equivalent Emissions Reduction (EER or Equivalent) option.

Compliance requirements for the ROPG pathway began in 2014 with a 50 percent visit and 50 percent power reduction requirement. This means a fleet must reduce its auxiliary engine power by 50 percent from the fleet's baseline power generation (baseline power generation equals a fleet's berthing time multiplied by the auxiliary engine[s] power requirement) during the vessel's stay on 50 percent of the fleet's annual vessel visits. These percentage requirements increased to 70 percent in 2017, and will increase to 80 percent in 2020, which will represent full implementation of the Existing Regulation. [23]

The EER pathway requires a percentage of emissions reduction below a fleet's baseline emissions. The baseline emissions for a vessel fleet is calculated by multiplying each individual vessel's berthing time with the vessel's electrical power requirements. Fleets following this pathway can comply using shore power or a CARB approved alternative

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[22] 17 CCR § 93118.3. Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port, https://ww3.arb.ca.gov/regact/2007/shorepwr07/93118-t17.pdf.

[23] 17 CCR § 93118.3. (d)(1), Reduced Onboard Power Generation Option, Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port, page 8, https://ww3.arb.ca.gov/regact/2007/shorepwr07/93118-t17.pdf.

control technology, such as a barge-based capture and control system. Compliance under this option began in 2010 with a 10 percent reduction and phased in to 50 percent in 2014 to match the ROPG pathway. Since 2014, the reduction requirements for both pathways have aligned at 70 percent in 2017 and 80 percent in 2020. [24]

The majority of vessels subject to the Existing Regulation comply using shore power. A small percentage of vessels that have not installed shore power use a CARB approved barge-based capture and control system for compliance. Barge-based capture and control systems can also be used in the event of shore power equipment failure or when a shore power berth is unavailable. Currently there are two barge-based CARB approved alternative technologies available for vessels to use for compliance in lieu of shore power. One system is located at POLA and the other at POLB.

3. Proposed Regulation

CARB staff are proposing adoption of the *Control Measure for Ocean-Going Vessels At Berth*, hereafter referred to as the "*Proposed Regulation*." The Proposed Regulation would supersede the Existing Regulation effective January 1, 2021.

The Proposed Regulation is designed to achieve added public health and air quality benefits. These benefits result from additional emissions reductions of DPM, PM2.5, NOx, ROG, and GHG, beyond those realized by the Existing Regulation. The Proposed Regulation accomplishes this by introducing emission control requirements to: additional ports and terminals, including marine terminals that operate independently from a port or port authority, and vessels not covered by the Existing Regulation.

The Proposed Regulation intends to simplify and streamline enforcement of the current regulatory requirements by using a regulatory structure different than the Existing Regulation. The Existing Regulation is a vessel fleet-based regulation with annual reporting requirements, whereas the Proposed Regulation contains emission control and reporting requirements based on individual vessel visits.

The Proposed Regulation would add two new vessel types: ro-ros and tankers.

To achieve further emissions reductions from vessels at berth, reduce adverse health impacts to communities surrounding ports and terminals, and increase clarity, and streamline enforcement of regulatory requirements for vessels, the Proposed Regulation includes the following the goal or benefit of each requirement:

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[24] 17 CCR § 93118.3. (d)(2), Equivalent Emissions Reduction Option, Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port, page 12, https://ww3.arb.ca.gov/regact/2007/shorepwr07/93118-t17.pdf.

The Proposed Regulation is designed to accomplish two main goals: achieve public health and air quality benefits, as described in Chapter A.4, and address implementation challenges with the Existing Regulation. To achieve further emissions reductions from vessels at berth, reduce adverse health impacts to communities surrounding ports and terminals, and streamline enforcement of regulatory requirements for vessels, the Proposed Regulation includes the following requirements and associated goals and benefits:

- Require vessels to control at berth emissions at additional ports and terminals beyond those covered under the Existing Regulation in order to increase the emissions reductions and reduce associated health impacts in additional communities.

- Require terminals that exceed the threshold of annual visits made by regulated vessels to control emissions from regulated vessels at berth. This allows ports growing in activity, and consequently their emissions burden to surrounding port communities, to be easily included in the regulation.

- Expand covered vessels to include ro-ro vessels, and tankers. Tanker vessel emissions make up the highest source of unregulated emissions from all vessels at berth statewide,[25] and the majority of ro-ro and tanker terminals exist in communities identified by CARB’s Community Air Protection Program (CAPP) as priority for the deployment of community air monitoring systems and/or community emissions reduction programs. Adding control requirements for ro-ro and tanker vessels plays a vital role in reducing vessel at berth emissions in these impacted port communities.

- Require small fleets to have compliance requirements in order to achieve the emissions reductions goals of the Proposed Regulation and provides a level playing field for all vessels of the same category.

- Include previously exempted auxiliary engines that operate on liquefied natural gas (LNG) or other alternative fuels to ensure that vessels are obtaining the require emissions reductions.

- Require tankers operating boiler steam powered pumps (for off-loading cargoes like crude oil) to control their boiler emissions in order to capture the majority of emissions from this category of tanker vessel. Tanker boilers make up nearly 40 percent of NOx emissions, 75 percent of PM2.5 emissions, and over 80 percent of GHG emissions from tanker vessels.[26]

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[25] California Air Resources Board, DRAFT: 2018/2019 Update to Inventory for Ocean-Going Vessels: Methodology and Results, (January, 2019), https://www.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf.

[26] California Air Resources Board, DRAFT: 2018/2019 Update to Inventory for Ocean-Going Vessels: Methodology and Results, (January, 2019), https://www.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf.

- Require all regulated vessel visits to use a CARB approved emissions control strategy to reduce auxiliary engine emissions and boiler emissions (for a subset of tanker vessels) on every visit to a regulated terminal, unless the visit qualifies for certain exceptions (to be discussed later in this list). Requiring every vessel to reduce emissions while at berth is necessary to achieve more emissions reductions from vessels at berth, particularly for the already regulated container, reefer, and cruise vessel categories.

- Implement a regulatory structure that is based on individual vessel visits. Placing control requirements on every visit simplifies compliance compared to the regulatory structure based on annual fleet visits in the Existing Regulation.

- Require ports and terminals to submit a plan to CARB describing what CARB approved emissions reduction strategy will be available to vessels visiting the terminal, and describing the necessary terminal and berth infrastructure modifications needed to reduce emissions from vessels at berth and the implementation timeline. Port and terminal plans are essential to help CARB staff understand and track how ports and terminals are planning to reduce emissions from vessels visiting their berths.

- Require both terminals and vessel operators to report corroborating information on vessel visits, including what technology was used to control emissions. Requiring both entities to report improves the accuracy of the data reported to CARB, allowing CARB enforcement staff the ability to corroborate visit information in the event of non-compliance during a visit.

- Require terminals and vessel operators to follow a compliance checklist that outlines all the steps necessary for a compliant visit. Compliance checklists allow regulated parties to determine compliance in a much shorter time frame than the Existing Regulation, where compliance may not be known for several months due to the annual fleet compliance structure of the regulation.

- Provide compliance options to address very difficult challenges with meeting requirements while a vessel is at berth. To address this, the Proposed Regulation provides mechanisms to account for both foreseeable and unforeseeable challenges that may prevent emissions reductions while not sacrificing significant emissions reductions. These provisions include safety exceptions and compliance options for shore power commissioning, research, terminal and incident events, and a remediation fund option.

- Require control technology developers to obtain CARB approval for their systems to be utilized as an emission control option and conduct periodic source testing. This ensures these technologies are achieving the emissions reductions required by the Proposed Regulation.

- Require all vessels visiting California regardless of port and terminal applicability, to maintain opacity standards at berth and at anchor.[27] This provision enforces existing state opacity standards, and provides clear authority for CARB enforcement staff to cite vessels at berth and at anchor if an opacity violation occurs.

The information provided in Table A2 shows terminals CARB staff expect to be included in the Proposed Regulation that are not currently affected by the Existing Regulation based on 2017 vessel visit data and the proposed terminal thresholds.[28] Ports and terminals would be subject to control requirements for a vessel type identified in the Proposed Regulation if the terminal receives 20 or more visits annually from container, reefer, ro-ro, cruise, tanker vessels, or any combination of these categories.

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[27] Opacity in relation to vessels at berth or anchor refers to the visual appearance of smoke emitting from the vessel's exhaust stack. There are standards set for non-vehicular air pollution sources of how dark the exhaust smoke can be, including for ocean-going vessels. These standards are defined in Health and Safety Code section 41701. https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=HSC&division=26.&title=&part=4.&chapter=3.&article=1.

[28] California State Lands Commission, CARB2017*,* April 2018.

Table A2: Location and Name of Terminals Affected by Proposed Regulation That Are in Addition to Those Affected by the Existing Regulation.

Terminal	Location
Wharf 2	Hueneme
Wharf 3	Hueneme
Vopak Long Beach	Long Beach
Tesoro - Pier T	Long Beach
Chemoil	Long Beach
Tesoro - Pier B	Long Beach
Cooper T. Smith	Long Beach
Crescent Terminal	Long Beach
Toyota Logistics	Long Beach
Vopak	Los Angeles
Valero	Los Angeles
PBF Energy	Los Angeles
Phillips 66	Los Angeles
Shell	Los Angeles
Yusen	Los Angeles
WWL	Los Angeles
National City Marine	San Diego
Pasha Terminal	San Francisco
Benicia - AM Ports	Benicia
Auto Warehouse Co.	Richmond
BP/ARCO	Richmond
Chevron - Richmond Long Wharf	Richmond
Phillips 66/Kinder Morgan	Richmond
IMTT	Richmond
Pacific Atlantic	Richmond
NuStar	Rodeo
Phillips 66	Rodeo
Pacific Atlantic	Carquinez
Shell	Carquinez
Tesoro - Avon	Carquinez
Tesoro - Amorco	Carquinez
Valero	Carquinez
Stockton Port Authority	Stockton

CARB staff gathered visit activity from CSLC and port Wharfinger data from calendar year 2017, which represented the most up to date visit information available to staff at the time of the analysis to help develop the terminal thresholds,. CARB staff explored multiple thresholds for the different vessel types during the regulatory development process, and after careful evaluation, propose a 20 visit terminal threshold for all vessel categories as this threshold includes the largest active container, reefer, and cruise, ro-ro, and tanker terminals in California. As terminal visit activity decreases, the cost effectiveness of installing emissions control equipment becomes worse, as there are fewer vessels calling at the terminal to use the equipment and to help recoup the costs of installing, operating, and maintaining the equipment.

This proposal provides a simplified approach to inclusion in the Proposed Regulation versus the Existing Regulation, where container and reefer fleets making 50 or more visits, or cruise fleets making 25 or more visits have control requirements at berth. Setting a 20 visit terminal threshold for the Proposed Regulation also ensures all the currently regulated ports still have control requirements. This has a dually positive effect by both preserving emissions reductions already occurring for the currently regulated port communities and preventing emissions control equipment investments that are already in use at ports for compliance with the Existing Regulation from becoming stranded assets.

The Proposed Regulation would phase in from 2021 through 2029. The proposed implementation timeline is summarized in Table A3. Based on 2017 CSLC visit data, the Proposed Regulation would require emissions control for approximately 6,500 annual vessel visits (out of roughly 8,000 total (includes regulated and unregulated) annual vessel visits to California). This represents an increase of approximately 2,500 vessel visits compared with the Existing Regulation at full implementation (2020).

Vessel categories currently regulated under the Existing Regulation would have new requirements beginning in 2021 under the Proposed Regulation. In addition, ro-ro vessels would have control requirements beginning in 2025, while tankers would have control requirements starting in 2027 for POLA and POLB and 2029 for the rest of the State.

The extended timeline for tankers takes into account that existing tanker terminals are designed with minimal wharf space, so most will need infrastructure improvements to handle the weight of new emissions control equipment, as well as additional piping and pilings. Also, marine oil terminals in Northern California can extend over a mile or more into the San Francisco Bay and Carquinez Straits, and can be affected by harsh weather conditions and strong currents. Combining these challenges with the extensive permitting and conservation restrictions placed on the San Francisco Bay, a longer timeline is expected for infrastructure projects being undertaken in Northern California. The earlier date for POLA and POLB tanker terminals also responds to the pressing need for NOx reductions in the South Coast Air Basin to attain the federal ozone air quality standard.

Table A3: Implementation Timeline for Proposed Regulation

Vessel Category	2021	2025	2027	2029
Container/Reefer	✓			
Cruise	✓			
Ro-Ro		✓		
Tankers			✓ POLA/POLB Terminals	✓ All California Terminals

The Proposed Regulation includes additional compliance options. These include Terminal Incident Events (TIEs) and Vessel Incident Events (VIEs), Remediation, and Safety/Emergency, Research, and Vessel Commissioning Exceptions. The primary objectives achieved through these compliance paths are to maintain a high level of emissions control, support terminal and port investments in one primary emission control technology, recognize the need to address operational challenges, and remediate excess emissions that occur during prolonged repairs of control equipment.

a. Terminal and Vessel Incident Events

TIEs and VIEs are compliance options that address instances when the operational needs of a terminal or vessel result in a vessel not being able to connect to an emissions control strategy. This compliance option recognizes the uncertainty that may surround vessel movements and cargo operations while a vessel is at berth. TIEs and VIEs can be used in the following situations:

- Terminal congestion, misalignment issues, or vessels that are berthed with the shore power plug on the opposite side from the vault, and

- The need for vessel redeployment (when a vessel operator needs to swap out a vessel previously in California service for a new vessel for any reason) by allowing vessel fleets to bring in a small number of infrequently visiting non-shore power vessels.

This compliance option reduces cost by eliminating the need for redundant emissions control systems. The number of TIEs and VIEs are capped to maintain a high level of emissions controlled for vessel visits to protect the surrounding port communities.

b. Remediation Fund

The remediation fund would allow terminals and vessels to comply with the Proposed Regulation by remediating lost emissions reductions through an hourly fee based on the cost of securing equivalent emissions reductions. This compliance option would be for when vessels and terminals have control strategies in place, but have visits that did not achieve reductions due only to the following circumstances:

- Extended vessel and terminal equipment repair
- Construction projects
- Delays in connecting to a control strategy (that result in a successful connection)
- Alternative control technology failure

The remediation fund is designed to allow vessel and terminal operators to mitigate the emissions associated with periods of uncontrolled vessel visits. Any remediation fees would be required to be invested into projects benefitting the communities affected by the uncontrolled emissions.

c. Exceptions

CARB staff understand there would be a few situations where achieving emissions reductions may not be feasible, including:

- Safety events and emergencies (including weather)
- Vessel commissioning
- CARB approved research projects

These situations would qualify for an exception from the control requirements.

4. Statement of the Need of the Proposed Regulation

The Proposed Regulation is designed to accomplish two main goals: achieve public health and air quality benefits, and address implementation challenges with the Existing Regulation. Existing regulations, port initiatives, and incentive programs have resulted in emissions reductions from vessels at berth. However, more action is needed to further reduce DPM and the localized cancer risk in communities surrounding ports and marine terminals, cut NOx and PM2.5 emissions to support regional attainment of health-based air quality standards for ozone and PM2.5, and reduce the GHG emissions that contribute to climate change. California is required under the Clean Air Act to achieve federal health-based air quality standards for ozone in 2023 and 2031 in the South Coast and San Joaquin Valley, and PM2.5 standards in the next decade. Achieving further NOx reductions through the Proposed Regulation is part of the State's Mobile Source Strategy and is critical to helping the South Coast Air Basin, which is home to the largest port complex in North America – POLA and POLB - to achieve National Ambient Air Quality Standards for ozone over the next decade. Under SB 32, California has set a GHG emissions reduction goal of 40 percent below 1990 levels by

2030 to reduce the impacts of global climate change. The Proposed Regulation will further reduce GHGs by increasing the use of clean grid-based power for vessels while they are at berth in California Ports.

The second important aspect of the Proposed Regulation is the need to address implementation challenges with the Existing Regulation. While implementing the Existing Regulation, CARB staff have been made aware of numerous operational challenges that make compliance with the Existing Regulation difficult to achieve, despite best efforts to comply from vessel crews and operators. Shore power connections require the terminal to provide a shore power capable vessel with an equally equipped shore power capable berth and appropriate labor to connect the vessel in a timely manner. If the terminal fails to provide a shore power connection for any reason, the vessel crew or operator has little recourse; if the vessel operates its auxiliary engines for longer than three hours, a compliant visit cannot be achieved under the Existing Regulation due to the way the regulation is constructed.

Some of the main operational issues impacting compliance with the Existing Regulation are:

- Unavailability of shore power for shore power equipped vessels
- Failure to meet the three hour/five hour time limit for connecting and disconnecting due to other parties and/or unexpected situations
- Commissioning visits are required by safety as per international regulations, yet not excluded in the Existing Regulation
- Challenge meeting compliance due to short visit calls

Several changes to the structure of the Existing Regulation are necessary to maximize emissions reductions from currently regulated vessel categories.

a. Many Portside Communities Are Disadvantaged

Many communities around California's ports and marine terminals bear a disproportionate heath burden due to their close proximity to the pollution generated from freight activity, including emissions from vessels (at berth, at anchor, during maneuvering, and while in transit) and other emission sources including trucks, locomotives, and terminal equipment. Many of these communities are classified as disadvantaged by the California Environmental Protection Agency (CalEPA), using the California Communities Environmental Health Screening Tool (CalEnviroScreen), Version 3.0,[29] developed by the Office of Environmental Health Hazard Assessment. CalEnviroScreen uses various factors to score California communities based on

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[29] Office of Environmental Health Hazard Assessment, CalEnviroScreen 3.0 (June 25, 2018), https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30 (last visited Oct. 23, 2018).

environmental pollution burden and socio-economic indicators. Exposure to DPM is a main contributor to many port communities scoring in the top 10th percentile statewide.

b. Emissions from Port Operations Pose an Unacceptable Health Risk

Since 2005, Health Risk Assessments conducted to quantify the excess cancer risk posed by the concentration of diesel-fueled engines operating in and around California's ports have consistently shown elevated localized risks to significant numbers of nearby residents.[30,31,32] Because of this, the Board supported staff's recommendation to prioritize further controls on vessels at berth due to their significant contribution to public health impacts including localized potential cancer risk.

As part of its Preliminary Health Analyses, CARB staff performed a Health Risk Assessment to evaluate the localized cancer impacts attributable solely to vessel emissions at berth at three California ports. Staff selected three ports to analyze based on port size, vessel activity, emissions, and proximity to disadvantaged communities. Staff selected POLA and POLB, and combined them in the analysis to represent large ports. The Richmond Complex was selected to represent small ports and tanker marine terminals. POLA and POLB combined represent more than half of the at berth emissions in California while the Richmond Complex represents the second largest emissions for tanker vessels in California.

Staff evaluated the potential cancer risk for the Maximum Exposed Individual Resident (MEIR) around POLA and POLB, as well as the MEIR around the Richmond Complex. The MEIR demonstrates the highest exposure at a location where an individual would live.

The Health Risk Assessment estimates the increase in potential cancer risk that would result from cargo growth under a business-as-usual scenario and the potential cancer risk reduction benefits of the Proposed Regulation.[33] The results of the Health Risk Assessment emphasize the need for the Proposed Regulation to provide public health benefits and reduce the cancer risk burden to communities surrounding ports and marine terminals.

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[30] California Air Resources Board, Diesel Particulate Matter Exposure Assessment Study For The Ports Of Los Angeles and Long Beach (April 2006), https://www.arb.ca.gov/ports/marinevess/documents/portstudy0406.pdf.

[31] California Air Resources Board, Diesel Particulate Matter Health Risk Assessment *For The West Oakland Community* (December 2008), https://ww3.arb.ca.gov/ch/communities/ra/westoakland/documents/westoaklandreport.pdf.

[32] Port of Long Beach and Port of Los Angeles Health Risk Assessment (ENVIRON POLA/POLB HRA)

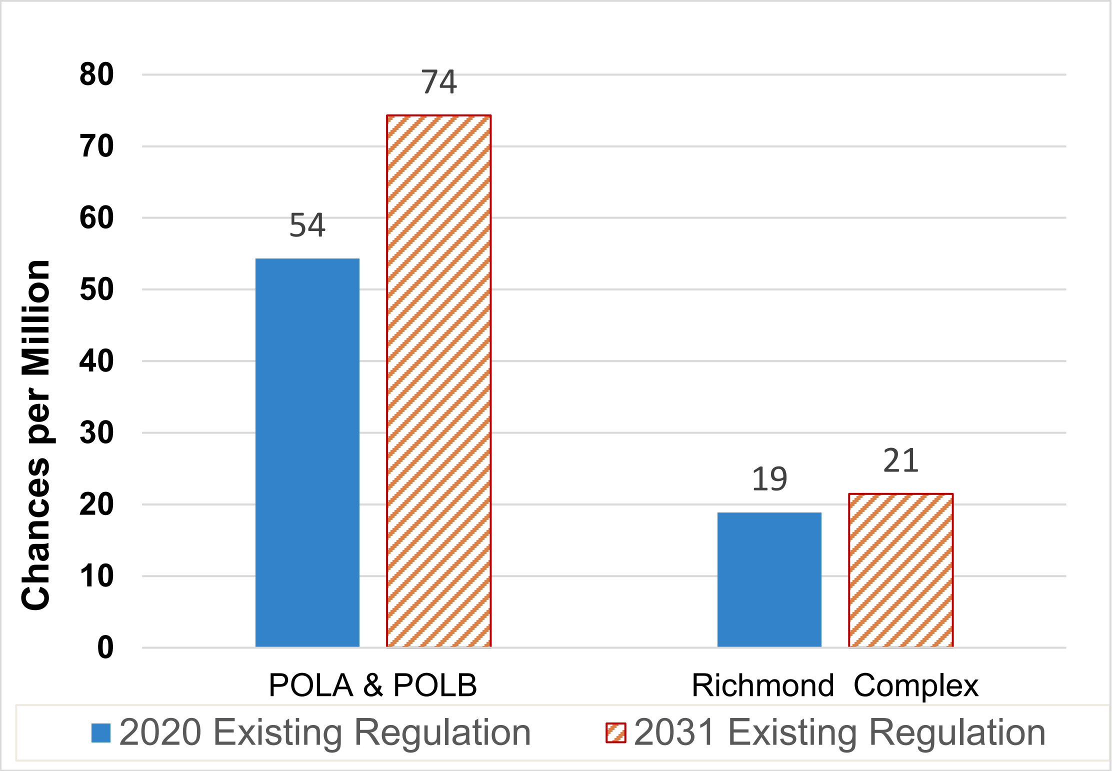
[33] California Air Resources Board, Preliminary Health Analyses: Control Measure For Ocean-Going Vessels At Berth And At Anchor (2018), https://www.arb.ca.gov/ports/shorepower/meetings/11052018/prelimhealthanalyses.pdf.

c. Cargo Growth Will Increase Emissions

Staff anticipates an increase in cargo shipping activity in upcoming years, which would result in an increase in emissions at California's ports for the foreseeable future, even as the Existing Regulation reaches full implementation.

A report published by Mercator International in 2016 estimates that cargo activity in the United States will grow 50 percent between 2021 and 2032, as measured in 20 foot-equivalent units (TEU), with activity at POLA and POLB projected to grow by 57 percent.[34] Based on these growth estimates, staff expect that DPM emissions from vessels at berth would increase by approximately 20 percent statewide through 2032 without additional regulations to reduce emissions. Figure A2 shows the increase in DPM related potential cancer risk in communities surrounding the POLA, POLB, and the Richmond Complex in a business as-usual-scenario (i.e., without the Proposed Regulation). The growth in emissions and potential cancer risk resulting from increased cargo growth would further exacerbate the health impacts to communities surrounding ports and marine terminals.

Figure A2. Maximum Exposed Individual Resident Potential Cancer Risk Baseline or Business-As-Usual Scenario (Existing Regulation)*



*MEIR cancer risk estimates are based on a 30-year exposure duration using the RMP method (95th/80th percentile daily breathing rate). FAH equals 1 for age bin <16 years, and 0.73 for age bin 16-30 years. All numbers are rounded.

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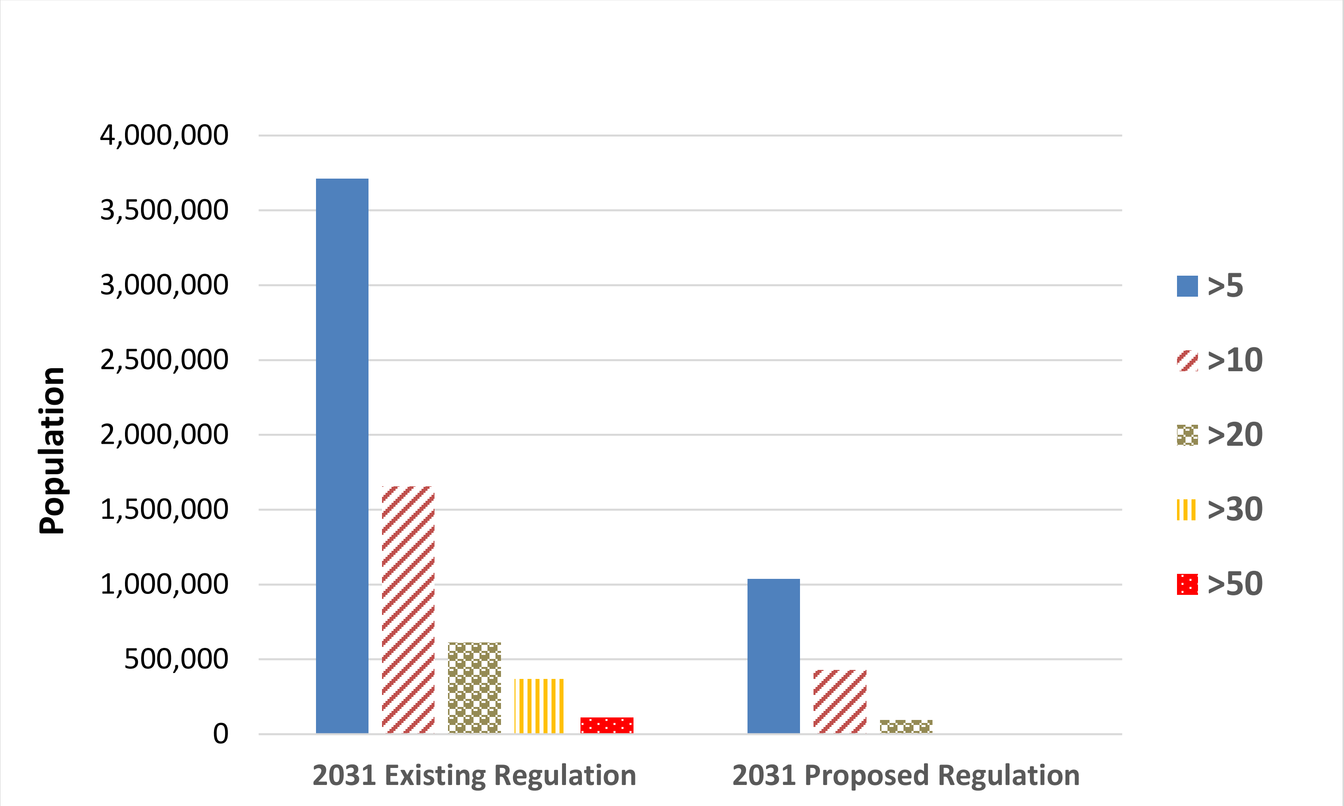
[34] Mercator International LLC, San Pedro Bay Long-term Unconstrained Cargo Forecast (July 12, 2016)

d. Need to Reduce the Localized Cancer Risk from Vessels At Berth

The results of the Health Risk Assessment emphasize the need for the Proposed Regulation to reduce the cancer risk burden to communities surrounding ports and marine terminals.

Figure A3 shows the population in communities affected by ocean-going vessels operating at berth in POLA and POLB in 2031 (without and with the Proposed Regulation).[35] Population-wide cancer risk numbers represent the estimated potential excess cancer risk over a 70-year exposure to DPM from this source. Many of these affected residents are in the State’s most disadvantaged communities.

Figure A3: Population (Number of Residents) Exposed to Elevated Cancer Risk (chances per million) from Vessels Operating At Berth in the South Coast Air Basin Without and With the Proposed Regulation



For POLA and POLB, the population’s exposure to a potential cancer risk level of greater than 30 chances per million would be eliminated with the Proposed Regulation, and the population exposed to other potential cancer risk levels would decrease significantly.

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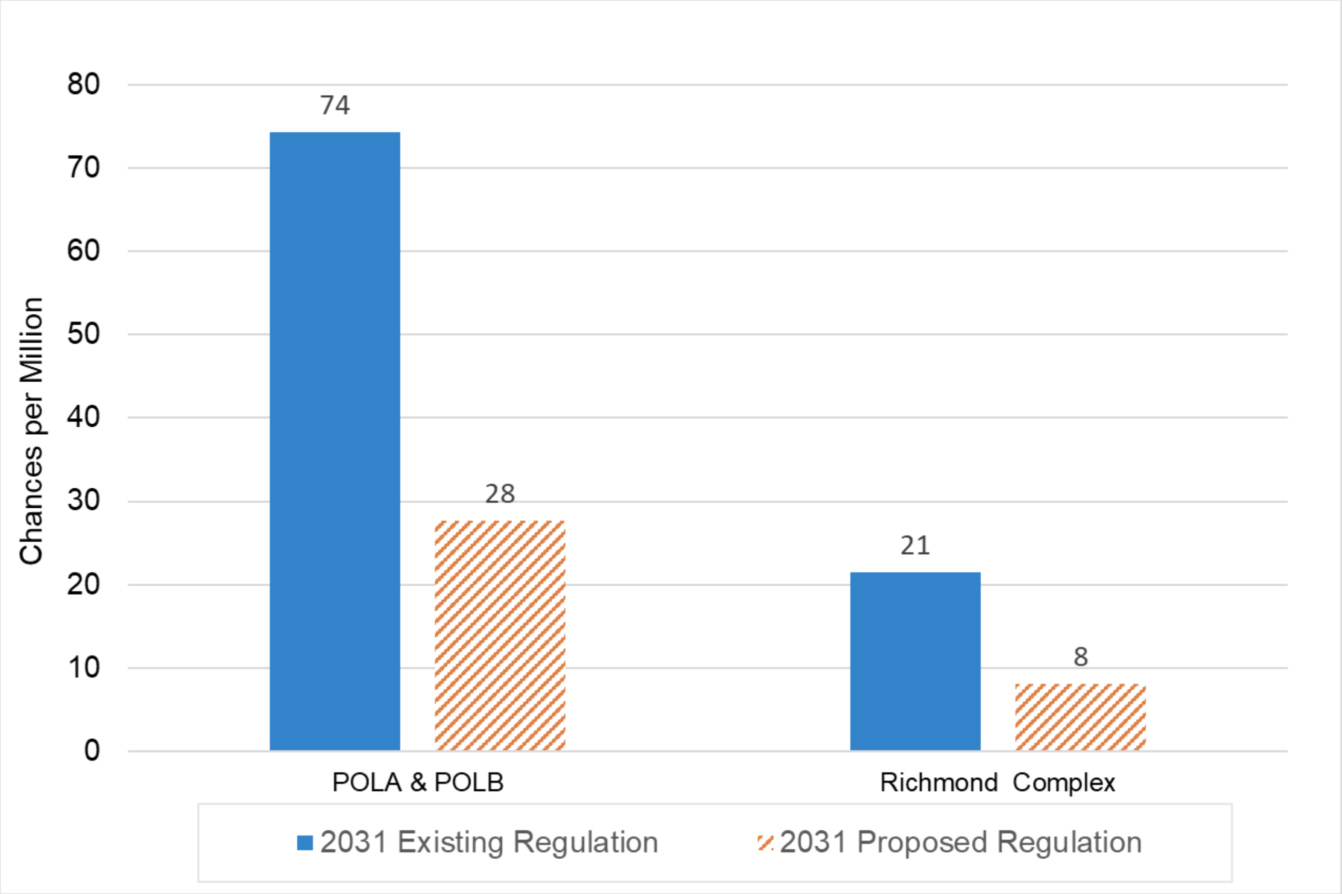
[35] Population-wide cancer risk estimates are based on a 70-year exposure duration.

Figure A4 shows that with full implementation of the Proposed Regulation, the potential cancer risk at POLA, POLB, and the Richmond Complex would be reduced significantly, compared to the Existing Regulation.

Figure A4: Maximum Exposed Individual Resident Potential Cancer Risk



For POLA and POLB, comparing the potential cancer risks with and without the Proposed Regulation in 2031, the MEIR potential cancer risk would decrease from approximately 74 chances per million to approximately 28 chances per million. This represents a reduction in potential cancer risk of more than 60 percent.

Similarly, for Richmond Complex, comparing the potential cancer risks with and without the Proposed Regulation in 2031, the MEIR potential cancer risk would decrease from approximately 21 chances per million to approximately 8 chances per million. Again, this represents a reduction in potential cancer risk of more than 60 percent.

e. *Need to Reduce Regional NOx and PM2.5 Emissions from Vessels At Berth*

Additional regulations are also needed to meet federal health-based air quality standards for ozone and PM2.5. Since NOx emissions also lead to the formation of PM2.5, NOx reductions achieved to meet ozone standards would also lead to improvement of PM2.5-related health impacts and attainment of PM2.5 standards.

Under the Clean Air Act, California is required to submit State Implementation Plans (SIPs) for areas that exceed the health-based National Ambient Air Quality Standards that illustrate how the State will attain the standards by certain dates.[36] CARB developed a State Strategy for the State Implementation Plan (State SIP Strategy) that was ultimately approved in 2017 by the U.S. Environmental Protection Agency (U.S. EPA). This State SIP Strategy provides CARB's commitment to take various proposed statewide control measures to the Board for consideration by specified dates and to achieve emissions reductions needed for attainment.[37] The Proposed Regulation is one of the control measures specified in the State SIP Strategy, therefore it is necessary to adopt this Proposed Regulation.

f. *Need to Reduce GHG Emissions from Vessels At Berth*

To reduce the mounting impacts of climate change, it is also important to cut emissions of GHGs and short-lived climate pollutants like black carbon from vessels. Staff estimated the reductions in GHGs and DPM provided by the Proposed Regulation, as described in Chapter B. Because black carbon is a component of DPM, reductions in DPM provide related reductions in black carbon.

Climate scientists agree that global warming and other shifts in the climate system observed over the past century are caused by human activities. These recorded changes are occurring at an unprecedented rate.[38] According to new research, unabated GHG emissions could cause sea levels to rise up to ten feet by the end of this century—an outcome that could devastate coastal communities in California and around the world.[39]

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[36] 42 U.S.C. §7410.(a)(1), Adoption of plan by State; submission to Administrator; content of plan; revision; new sources; indirect source review program; supplemental or intermittent control systems, State implementation plans for national primary and secondary ambient air quality standards, https://www.govinfo.gov/content/pkg/USCODE-2013-title42/html/USCODE-2013-title42-chap85-subchapI-partA-sec7410.htm.

[37] California Air Resources Board, Staff Report—ARB Review of 2016 Air Quality Management Plan for the South Coast Air Basin and Coachella Valley (2017), https://www.arb.ca.gov/planning/sip/planarea/scabsip/2016AQMP_ARBstaffreport.pdf.

[38] John Cook, et al., Consensus on consensus: a synthesis of consensus estimates on human-caused global warming (Apr. 13, 2016), Environ. Res. Lett. 11 (2016) 048002, doi:10.1088/1748-9326/11/4/048002, http://iopscience.iop.org/article/10.1088/1748-9326/11/4/048002/pdf.

[39] California Ocean Protection Council, Rising Seas in California: An Update On Sea-Level Rise Science (Apr. 2017), www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sealevel-rise-science.pdf (last accessed June 20, 2018).

California is already feeling the effects of climate change, and projections show that these effects will continue and worsen over the coming centuries. The impacts of climate change on California have been documented by the Office of Environmental Health Hazard Assessment (OEHHA) in *Indicators of Climate Change in California*[40], which details the following changes that are occurring already:

- A recorded increase in annual average temperatures, as well as increases in daily minimum and maximum temperatures [41]
- An increase in the occurrence of extreme events, including wildfire[42] and heat waves[43]
- A reduction in spring runoff volumes, as a result of declining snowpack[44]
- A decrease in winter chill hours, necessary for the production of high-value fruit and nut crops[45]
- Changes in the timing and location of species sightings

g. CARB's Authority and Responsibility to Reduce Air Pollution from Vessels At Berth

CARB would implement the Proposed Regulation to improve public health protection for local port communities as authorized by the California Health and Safety Code (HSC) and by other State legislation as follows:

- Health and Safety Code (HSC) 39650 et seq.[46] directs CARB to regulate toxic air contaminants from non-vehicular sources to reduce public exposure and risk.

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[40] Office of Environmental Health Hazard Assessment (OEHHA*),* Indicators of Climate Change in California (May 2018), https://oehha.ca.gov/media/downloads/climatechange/report/2018caindicatorsreportmay2018.pdf.

[41] Office of Environmental Health Hazard Assessment (OEHHA*),* Indicators of Climate Change in California (May 2018), page S-4, https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

[42] Office of Environmental Health Hazard Assessment (OEHHA*),* Indicators of Climate Change in California (May 2018), page 185 https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

[43] Office of Environmental Health Hazard Assessment (OEHHA*),* Indicators of Climate Change in California (May 2018), page 62 https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

[44] Office of Environmental Health Hazard Assessment (OEHHA*),* Indicators of Climate Change in California (May 2018), page 109, https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

[45] Office of Environmental Health Hazard Assessment (OEHHA*),* Indicators of Climate Change in California (May 2018), page S-5 https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf

[46] 26 California H.S.C. § 39650 et seq, Findings, Declarations and Intent, https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=HSC&division=26.&title=&part=2.&chapter=3.5.&article=1.

- HSC 43013[47] and 43018[48] direct CARB to control criteria air pollutants from mobile sources to attain air quality standards.

- Assembly Bill (AB) 32 (Chapter 488, Statutes of 2006)[49] and (Senate Bill (SB) 32 (Chapter 249, Statutes of 2016)[50] direct CARB to reduce greenhouse gases to specific levels to combat climate change.

- Senate Bill (SB) 605 (Chapter 523, Statues of 2014)[51] directed CARB to develop a comprehensive SLCP strategy, in coordination with other state agencies and local air quality management and air pollution control districts to reduce emissions of SLCPs.

h. State Policy and Plans Direct CARB to Secure Further Reductions from Vessels At Berth

State agencies over recent years have made numerous plans and commitments to reduce air pollution from freight sources.

In April 2015, CARB released the "*Sustainable Freight Pathways to Zero and Near-Zero Discussion Document* (Discussion Document)"[52] in response to Board Resolution 14-2,[53] which directed CARB to engage with stakeholders to identify and prioritize actions to move California toward a sustainable freight transport system. The Discussion Document set out CARB's vision of a clean freight system, and listed immediate and potential near-term CARB actions that staff would develop for future Board consideration. The near-term CARB measures identified in the Discussion Document included amending the Existing Regulation to include other vessel types to achieve additional emissions reductions.

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[47] 26 California H.S.C. § 43013, General Provisions, https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=43013.

[48] 26 California, H.S.C. § 43018, General Provisions, https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=HSC&sectionNum=43018.

[49] 25.5 California H.S.C. § 38500 – 38599, Assembly Bill No. 32, CALIFORNIA GLOBAL WARMING SOLUTIONS ACT OF 2006, http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf.

[50] 25.5 California H.S.C. § 38566, SB 32, Pavley, California Global Warming Solutions Act of 2006, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32.

[51] 26 California H.S.C. § 39730, SB 605, Lara, Short-lived climate pollutants, http://leginfo.ca.gov/pub/13-14/bill/sen/sb_0601-0650/sb_605_bill_20140921_chaptered.htm.

[52] California Air Resources Board, Sustainable Freight Pathways to Zero and Near-Zero Emissions Discussion Document (April 2015), California Sustainable Freight Initiative, https://www.arb.ca.gov/gmp/sfti/sustainable-freight-pathways-to-zero-and-near-zero-emissions-discussion-document.pdf.

[53] CARB Board Resolution 14-2, Sustainable Freight Strategy Update, January 23, 2014, https://arb.ca.gov/board/res/2014/res14-2.pdf.

In July 2015, Governor Brown signed Executive Order B-32-15[54] directing the secretaries of the California State Transportation Agency, CalEPA, and Natural Resources Agency to lead other relevant State departments in developing an integrated action plan by July 2016 that "establishes clear targets to improve freight efficiency, transition to zero-emission technologies, and increase competitiveness of California's freight system." The 2016 California Sustainable Freight Action Plan includes strengthening the Existing Regulation as a State agency action to advance the objectives of the Executive Order and the Sustainable Freight Action Plan. [55]

In September 2016, the Board approved the 2016 State SIP Strategy, which describes CARB's proposed commitment to achieve the emissions reductions from mobile sources and consumer products needed to meet federal air quality standards over the next 15 years. [56] The State SIP Strategy includes an enforceable commitment for specific emissions reductions, along with commitments to develop and propose a list of specific measures. CARB's list includes actions to strengthen the emission controls from vessels at berth by including additional vessel fleets, types, and operations.

In July 2017, Governor Brown took action to continue California's work to reduce air pollution by signing a legislative package establishing a new program to improve air quality in local communities (AB 617; Chapter 136, Statutes of 2017). [57,58] The legislation helps ensure California continues to meet its air quality standards while addressing air pollution in communities with the dirtiest air. More work is needed to reduce the public health impacts in these communities that experience a significant burden from air pollution. With respect to AB 617, CARB has begun work to implement a new community-focused air quality program, including monitoring and emissions reduction plans. The Proposed Regulation would address community air quality objectives.

In 2006, California enacted AB 32 to address this public problem by requiring cost-effective reductions in GHG emissions and by codifying a target of reducing California GHG emissions to 1990 levels by 2020. AB 32 directed CARB to continue its leadership role on climate change and to develop a scoping plan identifying integrated and cost-effective regional, national, and international GHG reduction programs.[59] In 2015, Governor Brown issued Executive Order B-30-15 (EO B-30-15),[60] which set a goal of reducing statewide GHG emissions to 40 percent below 1990 levels by 2030. In

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[54] Executive Order B-32-15, July 17, 2015, https://www.ca.gov/archive/gov39/2015/07/17/news19046/index.html.

[55] California Department of Transportation et al., California Sustainable Freight Action Plan, Appendix C. (July 2016), http://dot.ca.gov/hq/tpp/offices/ogm/cs_freight_action_plan/Documents/CSFAP_AppendixC_FINAL_07272016.pdf.

[56] California Air Resources Board, Revised Proposed 2016 State Strategy for the State Implementation Plan March 7, 2017, http://www.arb.ca.gov/planning/sip/2016sip/2016sip.htm.

[57] AB 398, 25.5 California H.S.C. § 38501, 38562, 38594, 8505.5, 38590.1, 38591.1-38591.3, 38592.5, 38592.6, 4213.05 (2017).

[58] 25.5 California H.S.C. § 40920.6, 42400, 42402, 39607.1, 40920.8, 42411, 42705.5, 44391.2 (2017).

[59] AB 32, 25.5 California H.S.C. § 38500 – 38599, California Global Warming Solutions Act Of 2006

[60] Executive Order B-30-15, April 29, 2015, https://www.gov.ca.gov/2015/04/29/news18938/

2016, the Legislature passed, and Governor Brown signed, SB 32, which codified the 40 percent reduction goal from 1990 levels by 2030.[61]

5. Major Regulation Determination

The Proposed Regulation has been determined to be a major regulation requiring a Standardized Regulatory Impact Assessment (SRIA), based on estimated costs that are projected to exceed $50 million in a 12-month period during the period of analysis, 2020 through 2032.

6. Baseline Information

To estimate the economic impacts of the Proposed Regulation, a baseline or business-as-usual (BAU or Baseline) scenario was developed. The economic impact of the Proposed Regulation is evaluated in comparison with the Baseline scenario. The Baseline scenario assumes full compliance with the Existing Regulation in 2020, the first year of the most stringent emissions reduction requirements. According to CARB's 2017 Annual Enforcement Report, based on a statewide average, fleets met the 50 percent power reduction requirement of the Existing Regulation, indicating that fleets achieving the required emissions reductions of the Existing Regulation.

Under the Existing Regulation, affected vessel fleets are required to follow one of two pathways for compliance:

- Reduced Onboard Power Generation (Shore Power) Option– fleets utilize shore power for a specified percentage of port visits, while also reducing their baseline power generation by a specified percentage or use various control measures to achieve equivalent at berth emissions reductions; or

- Equivalent Emissions Reduction (Equivalent) Option – fleets reduce emissions by a specified percentage using shore power or a CARB approved alternative technology.

Compliance under the Equivalent Option began in 2010 with a 10 percent reduction and phased in to 50 percent in 2014 to match the Shore Power pathway. Since 2014, the reduction requirements for both pathways have aligned at 70 percent in 2017 and 80 percent in 2020. The 80 percent reduction requirement in 2020 represents full implementation of the Existing Regulation.

In addition to the Existing Regulation, the Baseline scenario assumes full compliance with the Vessel Clean Fuel Regulation and International Maritime Organization (IMO)

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[61] SB 32, Pavley, 25.5 California H.S.C. § 38566, https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32

emission standards for vessel engines. [62,63,64] The Vessel Clean Fuel Regulation reduces DPM, NOx and sulfur oxide (SOx) emissions from ocean-going vessels to improve air quality and public health in California. At full implementation on January 1, 2014, the Vessel Clean Fuel Regulation required that the vessels operate on clean distillate fuel (marine gas oil or marine diesel oil at or below 0.1 percent sulfur) while transiting, maneuvering and at berth within 24 nautical miles of the California shoreline.

The Baseline scenario assumes that after 2020, both the Existing Regulation and the CARB Vessel Clean Fuel Regulation will continue to provide reductions consistent with full implementation of the regulations.

For forecast years in the inventory, staff applied growth forecasts based on the U.S. Federal Highway Administration's Freight Analysis Framework (FAF) [65] for most ports in the State.[66] In two instances port specific forecasts were available and used instead of the FAF. The Mercator Group provided growth forecasts for POLA and POLB specifically, including container vessel size trends.[67] For Port of Hueneme, growth trends were forecast based on Port of Hueneme cargo data.[68] Staff modeled growth from 2017 to 2050. Tables for growth factors at each California port are available in Appendix C of CARB's DRAFT: 2018/2019 Update to Inventory for Ocean-Going Vessels: Methodology and Results (2018/2019 draft Inventory Methodology).[69]

While vessel activity (where activity is the total statewide at-berth power requirements in kilowatt hours) is projected to increase post 2020, for this analysis, staff assumed that the shore power infrastructure installed to meet the 2020 requirement would be sufficient to meet future demand from vessel activity growth. Figure A6 shows statewide emissions estimate for PM2.5 and NOx in tons per year (TPY) for the business-as-usual Baseline from 2020 to 2032.

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[62] California Air Resources Board, 13 C.C.R. §Section 2299.2, Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels Within California Waters and 24 Nautical Miles of the California Baseline (2011), https://ww3.arb.ca.gov/regact/2011/ogv11/ogv11.htm.

[63] International Maritime Organization, Prevention of Air Pollution from Ships Annex VI, http://www.imo.org/en/ourwork/environment/pollutionprevention/airpollution/pages/air-pollution.aspx.

[64] International Maritime Organization, New Engine NOx Emissions Limits Under IMO Annex VI, http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Nitrogen-oxides-(NOx)-–-Regulation-13.aspx.

[65] US Department of Transportation, Freight Facts and Figures 2017, Freight Analysis Framework v4.3.1 (Mar. 2017), https://www.bts.gov/product/freight-facts-and-figures.

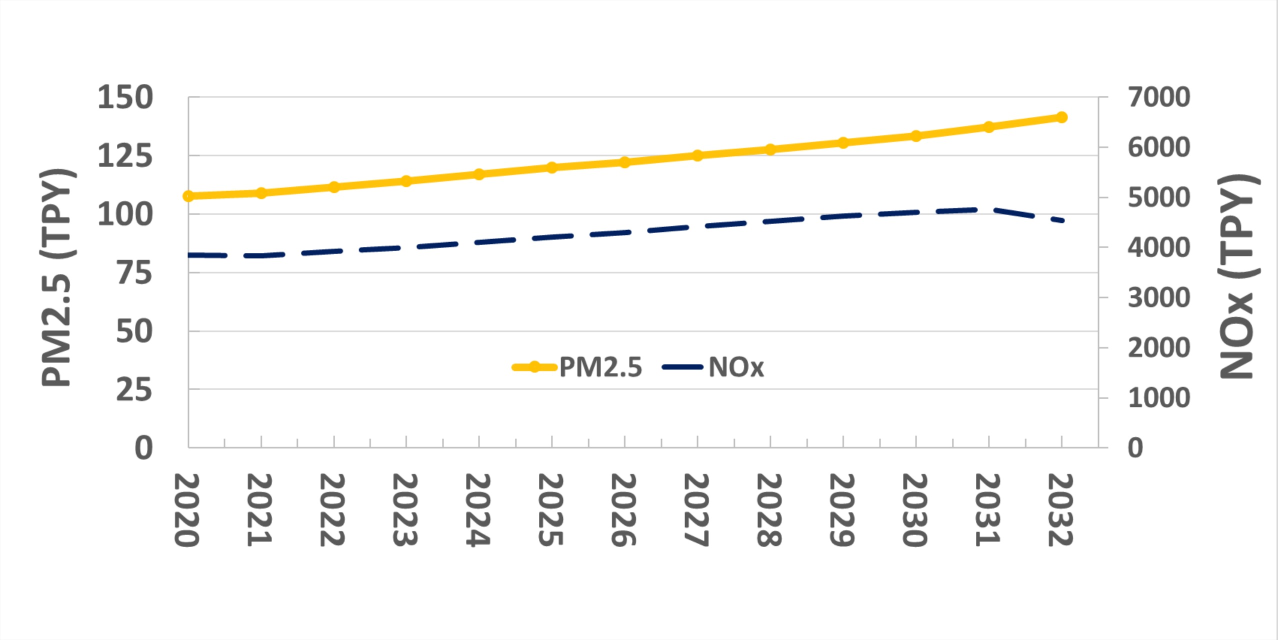
[66] US Department of Transportation, Freight Facts and Figures 2017, Freight Analysis Framework v4.3.1 (Mar. 2017), https://www.bts.gov/product/freight-facts-and-figures.

[67] Mercator, San Pedro Bay Long-term Unconstrained Cargo Forecast (July 12, 2016), Mercator International LLC, Oxford Economics.

[68] Historical growth rates from 2004 to 2014 based on Port of Hueneme cargo data.

[69] California Air Resources Board, DRAFT: 2018/2019 Update to Inventory for Ocean-Going Vessels: Methodology and Results, (January, 2019), https://www.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf.

Figure A6: Statewide Business-As-Usual Baseline Emissions Estimates (TPY)



7. Public Engagement

During the course of the rulemaking for the Proposed Regulation since late 2014, CARB staff conducted more than 60 individual meetings with members of impacted communities, environmental justice advocates, air districts, industry stakeholders (including vessel operators, ports, terminal operators, industry associations, alternative technology operators), U.S. Coast Guard, CSLC, and other agencies. Meeting formats included public workshops, work group meetings, community meetings, and individual meetings with stakeholders.

Staff also held various meetings, teleconferences, and webinars with trade associations, technology providers, vessel operators, terminal operators, port authorities and the communities surrounding the seaports, to discuss staff's proposal and gather input and information. Staff toured many California seaports and marine terminal complexes to learn more about their individual business operations and understand the scope of challenges facing the industry and the surrounding community. Additionally, staff toured multiple vessels including bulk, container, tanker, and ro-ro vessels to learn about their unique layout and operational challenges.

Staff held numerous meetings and teleconferences with industry associations, individual manufacturers, and groups of industry representatives to gather information and receive input on staff's proposal. Among the industry associations represented were Pacific Merchant Shipping Association, World Shipping Council, Western States Petroleum Association, California Association of Port Authorities, Cruise Lines International Association, and Chamber of Shipping (of United States and Canada). Discussions were also held with representatives from the International Longshore and Warehouse Union, who play a vital role in the shore power connection process for vessels calling at California seaports, manufacturers of engine and emissions reductions technologies for vessels, including MAN Diesel and Turbo, Wärtsilä, and Alfa Laval, and shore power equipment manufacturers including CAVOTEC. Throughout the regulatory process, staff also consulted with multiple government agencies, including U.S. EPA, U.S. Coast Guard, California Office of Spill Prevention and Response, California local air districts, CSLC, and Harbor Safety Committees in San Francisco, as well as Los Angeles and Long Beach. Additionally, staff is actively engaged with the alternative capture and control system manufacturers, Advanced Cleanup Technologies (Advanced Environmental Group or AEG) and Clean Air Engineering – Maritime, as well as new emerging companies including Stax Engineering.

CARB staff conducted workshops open to the public to discuss the developments of the Proposed Regulation. All of the workshops were announced with issuance of a public workshop notice at least three weeks prior to their occurrence. The public notices were posted to the program's website at https://www.arb.ca.gov/ports/shorepower/shorepower.htm and sent to over 3,800 subscribers of the Ocean-Going Vessels and Shorepower for Ocean-Going Vessels public email List serves.

The first workshop was held on November 6, 2014 in Sacramento, California and introduced the idea of potential regulatory amendments to address initial challenges seen during implementation of the regulation. The discussed focused on approaches to potentially enhance the Proposed Regulation's expected emissions benefits. [70] CARB staff also sought additional public input on implementation challenges and stakeholder feedback on preliminary concepts to modify the regulation requirements to address these challenges. The workshop was webcast with the ability to submit online questions to increase participation in the discussion.

A second series of workshops took place on August 28, 2017, in Los Angeles, California and on September 7, 2017 in Sacramento, California. [71] The workshops included a presentation summarizing the current implementation of the regulation, an emissions inventory update, and further developed draft regulatory concepts. Fifty-five participants attended the Los Angeles workshop and an additional 40 participants attended the Sacramento workshop. The Sacramento workshop was webcast to increase public participation.

Regulatory staff participated in four broader freight-focused community meetings during the week of September 18, 2017 in Lamont, Long Beach, Fontana, and Oakland, with more than 130 attendees in total, including local residents and more than

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[70] California Air Resources Board, November 05, 2014 15:55:31 -- List Name: shorepower, https://ww3.arb.ca.gov/docs/whatsnew/arch14.htm

[71] Catalina Island Chamber of Commerce & Visitors Bureau, *Post August 28, 2017 Workshop Comments (October 5, 2017),* https://ww3.arb.ca.gov/ports/shorepower/meetings/082817/workshopcomments.pdf

70 organizations.[72] The meetings were held using the World Café method, with one to two CARB staff members at a table with multiple community members. The tables were divided into discussion topics for: seaports, rail yards, warehouses, and distribution centers.

Staff also participated in a joint AB 617 community meeting in San Diego, on November 28, 2017.[73] This meeting was to facilitate discussion and answer questions on concepts to control pollution from freight facilities and reduce exposure in the communities most affected by air pollution. Participants gathered in small groups to discuss their views and raise questions regarding pollution at seaports, border crossings, and warehouses.

Community members voiced their concerns related to impacts on communities from freight facilities, diesel soot, smog/local air quality, and odors, noise, and light. Residents also described the health impacts (e.g., asthma and cancer) they are experiencing, particularly to children and elderly in the affected neighborhoods. Community members emphasized the need to improve enforcement of CARB regulations to reduce smoking from truck, vessel, and locomotive engines. Community members expressed support for zero-emission operations, such as shore power, and improved infrastructure at local seaports. Advocates also pushed CARB for improved enforceability, more transparency, and better cooperation between state and local agencies.

To assist with this effort, staff sent a series of surveys to ports, terminal operators, and vessel operators, requesting information on the costs to install vessel-side and port-side shore power equipment. The surveys were distributed via List serve in April 2018, to ports and in June 2018, to container, bulk, ro-ro, tanker, and cruise vessel operators, as well as to terminals. Participants were given a month to respond to the surveys. Of the 79 vessel survey recipients, 16 returned the survey to CARB. Of the 18 port terminal survey recipients, six returned the survey. The information provided was aggregated, combined with other data sources, and used in staff's cost assumptions and estimates. Information requested via the surveys is further discussed in Chapter C. Direct costs, and details on the information CARB received in response to the survey is provided in Attachments B and C.

CARB staff extended its outreach to communities surrounding seaports and affected by the ocean-going vessel activity by participating in meetings and monthly calls with the California Cleaner Freight Coalition (CCFC). These monthly calls focused on updating community advocacy groups on the development process of CARB's freight-related regulatory activities. In addition, regulatory staff met with representatives from the CCFC on July 13, 2018, in Sacramento and on September 21, 2018, in Long Beach to

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[72] California Air Resources Board, Minimizing Community Health Impacts From Freight Facilities (September 2017), https://ww3.arb.ca.gov/gmp/sfti/freight%20facilities%20community%20mtgs.pdf

[73] California Air Resources Board, Minimizing Community Health Impacts From Freight Facilities and Community Air Protection Program (November 2017), https://ww3.arb.ca.gov/gmp/sfti/freight_ab617_community_mtg_san_diego_11-20-2017.pdf

hear community advocates' ideas and comments, and to discuss staff's draft concepts for the Proposed Regulation.

CARB staff hosted a webinar on July 19, 2018, with industry stakeholders to discuss staff's preliminary concepts for the Proposed Regulation. The webinar walked participants through the purpose of the draft regulatory concepts and preliminary implementation schedule, the method for determining which vessels and ports would be included in the regulation, and responsibilities for vessel owners/operators, terminals, ports, and alternative technology providers. During this webinar, staff specifically requested stakeholders to submit proposed regulatory alternatives for the economic analysis.

CARB staff also held four work group meetings in August 2018, specifically to discuss the expected costs to industry from the Proposed Regulation.[74] These meetings were held with participants from ports, terminals, and container, reefer, cruise, ro-ro, bulk, general, and tanker vessel operators. Staff distributed preliminary cost estimates in advance of the meetings, and met separately with each industry sector. Based on the industry feedback, CARB staff substantially revised its initial cost estimates. At the meetings, staff again requested suggestions for regulatory alternatives from the stakeholders present.

The third series of workshops took place on September 6, 2018, in Oakland, California and on September 17, 2018 in San Pedro, California. [75] At these workshops, staff presented refined regulatory concepts, [76] preliminary cost analysis, [77] estimates of emissions and health risk reductions. During the September 6, 2018, and September 17, 2018, workshops, staff also solicited early scoping feedback on the environmental analysis that will be prepared for this regulatory action, and solicited alternatives for this Standardized Regulatory Impact Analysis (SRIA). These workshops also served as a California Environmental Quality Act (CEQA) scoping meeting. There were 55 participants who attended the Oakland workshop and 76 participants at the San Pedro workshop. No webcast options were available for either of these workshops which were held at non-CARB facilities that did not provide webcasting.

A fourth set of public workshops took place on May 14, 2019 in Sacramento, California and on May 16, 2019 in Long Beach, California. [78] At these workshops, staff presented updates to the draft regulatory language version that was posted to CARB's shore

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[74] California Air Resources Board, At-Berth Regulation Preliminary Cost Information, August 14, 2018 - Preliminary Cost Analysis, https://ww3.arb.ca.gov/ports/shorepower/meetings/08152018/costinformation.pdf.

[75] California Air Resources Board, September 6 & 17, 2018 - 2nd Public workshops, https://ww3.arb.ca.gov/ports/shorepower/meetings/09062018/presentation.pdf.

[76] California Air Resources Board, Draft Regulatory Language, September 6 & 17, 2018 - 2nd Public workshops, https://ww3.arb.ca.gov/ports/shorepower/meetings/09062018/draftreg.pdf.

[77] California Air Resources Board, Preliminary Cost Analysis Materials, September 6 & 17, 2018 - 2nd Public workshops, https://ww3.arb.ca.gov/ports/shorepower/meetings/08152018/costinformation.pdf.

[78] California Air Resources Board, May 14 & May 16, 2019 - Public Workshops, https://ww3.arb.ca.gov/ports/shorepower/meetings/051419/presentation.pdf.

power website in September 2018, refined regulatory concepts, updated cost analyses,[79,80] and estimates of emissions and non-cancer health valuation benefits. There were 24 participants who attended the Sacramento workshop and 48 participants at the Long Beach workshop. The Sacramento workshop was webcast to ensure the opportunity for broader public participation.

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[79] California Air Resources Board, Draft Cost Inputs and Assumptions, May 14 & May 16, 2019 - Public Workshops, https://ww3.arb.ca.gov/ports/shorepower/meetings/051419/costassumptions.pdf.

[80] California Air Resources Board, Draft Cost Estimates, May 14 & May 16, 2019 - Public Workshops, https://www.arb.ca.gov/ports/shorepower/meetings/051419/costestimates.xlsx.

B. BENEFITS

1. Emission Benefits

a. Emission Inventory Methodology

CARB staff estimated emissions for vessels operating at berth based on the best available information regarding past, current, and projected future vessel activity. Emissions for PM2.5, DPM, NOx, ROG and GHGs were estimated for the Proposed Regulation, Alternative 1 and Alternative 2. All three scenarios are compared to the baseline. The following paragraphs describe the methodology staff used to develop the emissions estimates.

Emissions benefits from the Proposed Regulation would begin in 2021, when the first emission control requirements would be scheduled to take effect. Staff quantified emissions benefits through 2032, which is consistent with the timeframe used for the cost analysis. Staff developed the statewide emissions estimates for the Proposed Regulation based on the following implementation phases:

- Phase 1: Would begin in 2021 and require use of a CARB approved emission control strategy capable of achieving at least 80 percent emissions control on applicable container, reefer, and cruise vessel auxiliary engines.

- Phase 2: Would begin in 2025 and require use of a CARB approved emission control strategy capable of achieving at least 80 percent emissions reductions on applicable ro-ro vessel auxiliary engines.

- Phase 3: Would begin in 2027 and require use of a CARB approved emission control strategy capable of achieving at least 80 percent emissions reductions for all applicable Los Angeles and Long Beach tanker vessel auxiliary engines and tanker boilers that are used to power steam-driven pumps to load and off load product.

- Phase 4: Would begin in 2029 and require use of a CARB approved emission control strategy capable of achieving at least 80 percent emissions reductions for all remaining tanker vessel auxiliary engines and tanker boilers that are used to power steam driven pumps to load and off-load product.

CARB approved emission control strategies must achieve, at minimum, an 80 percent reduction of PM2.5, DPM, NOx, and ROG and GHGs must be less than or equal to the level emitted when using grid electricity to power the system

Alternative 1 considers an all shore power regulation where alternative control strategies are not included. Alternative 2 considers the proposed regulation but excludes controls for vessels. Alternatives 1 and 2 are described in Chapters F.1 and F.2, respectively.

CARB's 2018/2019 draft Inventory Methodology estimates emissions using the best available data for ocean going vessels. The 2018/2019 draft Inventory Methodology uses a 2016 baseline and forecasts emissions for future years for each vessel type, engine type (i.e., auxiliary engine or boiler) and pollutant. [81]

The basic equation used to calculate per engine or boiler emissions is as follows:

$$\boldsymbol{E} = EF \times KW \times LF \times hr$$

Where:

> *E* is the amount of emissions of a pollutant (NOx, PM2.5, DPM, ROG and GHGs) emitted during one at berth visit;
> *EF* is the auxiliary engine or boiler emission factor;
> *KW* is rated power of the auxiliary engine or boiler in kilowatts;
> *LF* is the load factor (actual engine power used divided by the total installed engine power); and
> *hr* is the at berth visit stay time.

The 2016 base year inventory is determined by calculating engine and boiler emissions per vessel visit and summing the emission for all the vessel visits at each port using the following data sources. IHS-Markit[82] and the Marine Exchange[83] data provide vessel-specific information for vessel visits to California including visit locations, duration of stays, vessel type, vessel size, and rated main engine power. Rated power and load factor multiply to result engine effective power. Auxiliary engine and boiler power and load were derived from POLA and POLB inventories per vessel type and vessel size.[84,85] Emission factors for ocean going vessels were selected to be consistent with International Maritime Organization (IMO) and US EPA, and are listed in Appendix A of CARB's 2018/2019 draft Inventory Methodology.

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[81] California Air Resources Board, DRAFT: 2018/2019 Update to Inventory for Ocean-Going Vessels: Methodology and Results, (January 2019), https://www.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf.

[82] IHS-Markit 2016 Vessel Visit Data for California

[83] South Coast Marine Exchange 2016 Arrival/Departure Data

[84] Starcrest Consulting Group, LLC, Port of Los Angeles Inventory of Air Emissions – *2016*, Technical Report APP# 160825-520 A (July 2017), https://kentico.portoflosangeles.org/getmedia/644d6f4c-77f7-4eb0-b05b-df4c0fea1295/2016_Air_Emissions_Inventory.

[85] Starcrest Consulting Group, LLC, *Port of Long Beach* Air Emissions Inventory – *2016 (July 2017),* http://www.polb.com/civica/filebank/blobdload.asp?BlobID=14109.

b. Anticipated Emissions Reduction Benefits

The Proposed Regulation is expected to reduce emissions of PM2.5, DPM, NOx, ROG and GHGs beyond levels achieved under the Baseline. Staff estimated that from 2021 through 2032, the Proposed Regulation would further reduce cumulative statewide emissions by approximately 390 tons of PM2.5, 310 tons of DPM, 20,000 tons of NOx, 900 of tons ROG, and 400,000 metric tons (MT) of GHG, relative to the Baseline. Emissions reductions will begin in 2021 when the Proposed Regulation imposes emissions reduction requirements on previously unregulated vessels in the cruise, container, and reefer vessel categories. GHG emissions reductions would be achieved when vessels comply using shore power. This is because GHG produced by the electrical grid are approximately 65 percent lower than those produced from burning fuel in vessel auxiliary engines for the same electrical power.

For the Proposed Regulation, emissions reductions would continue to increase as requirements for ro-ro vessels would be implemented in 2025, tankers at POLA and POLB would be implemented in 2027, and all remaining tankers would be implemented in 2029.

Emissions reductions estimates reported in CARB’s 2018/2019 draft Inventory Methodology were updated in May 2019 to reflect revisions to the tanker vessel implementation schedule from 2025 and 2031 to 2027 and 2029. [86] While the inventory methodology is the same as described in the 2018/2019 draft Inventory Methodology, the emissions estimates reported in this document reflect the May 2019 updates. Table B1 summarizes estimated emissions reductions that would result from the Proposed Regulation from 2021 through 2032.

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[86] California Air Resources Board, Public Workshop to Discuss Draft New At Berth Regulation (May 14, 2019), https://ww3.arb.ca.gov/ports/shorepower/meetings/051419/presentation.pdf.

Table B1: Projected Annual and Total PM2.5, DPM, NOx and GHG Emissions Reductions Resulting from the Proposed Regulation from 2021 – 2032

Year	PM2.5 (Tons)	DPM (Tons)	NOx (Tons)	ROG (Tons)	GHG (MT)
2021	12	13	810	35	32,000
2022	13	14	850	37	34,000
2023	15	16	1,000	45	41,000
2024	16	17	1,000	47	43,000
2025	20	22	1,300	59	43,000
2026	21	23	1,400	61	44,000
2027	36	28	1,800	83	31,000
2028	38	29	1,900	86	33,000
2029	51	36	2,400	110	22,000
2030	53	37	2,400	110	24,000
2031	55	39	2,500	110	26,000
2032	56	40	2,300	120	28,000
Total	390	310	20,000	900	400,000

2. Benefits to Typical Businesses

The Proposed Regulation is expected to result in benefits to capture and control system manufacturers, crane manufacturers, barge manufacturers, component suppliers (including ducts and piping), electrical suppliers, design, engineering, and construction firms. There are two manufacturers of the capture and control systems, both with operations in California: Clean Air Engineering[87] and Advanced Cleanup Technologies.[88] CARB staff estimated that 7 barge-based and 33 land-based systems would be needed to control emissions from approximately 2,900 vessel visits annually with the majority of these visits being tanker and ro-ro vessels. CARB staff determined that these two vessel types are most likely to use these systems as the majority of vessels make infrequent visits to California ports and are unlikely to install shore power due to cost. The land-based capture and control systems require infrastructure to support the system and the crane, which would result in increases in construction materials and jobs in the State. The increase in the production and usage of the capture and control systems could also benefit various businesses related to the

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[87] Tri-Mer Marine Air Systems, MARITIME EMISSIONS TREATMENT SYSTEM (METS), https://tri-mer.com/pdf/TriMer-MET-Brochure.pdf.

[88] Advanced Cleanup Technologies, Emissions Control System, http://www.advancedcleanup.com/index.php?article=2.

component supply chain, including manufacturers of selective catalytic reduction control equipment. Staff expects that these two businesses will see more business as well as other companies as staff has been actively engaged with three emerging companies. The Proposed Regulation is also expected to benefit companies that install shore power equipment on vessels and at ports and terminals. CARB staff have estimated that 57 container/reefer vessels and 26 cruise vessels would need to be retrofitted for shore power. Staff also estimated that five additional shore power vaults systems and one additional shore power berth would be needed to accommodate the additional vessel visits that would use shore power. The vessel retrofits are typically not done in California, however, all of the landside shore power installations would take place in California. Some of this equipment may be manufactured in California.

The Proposed Regulation could also provide benefits in the form of lower fuel costs for vessels that have installed shore power and LCFS credits for terminals and ports.[89] These are described in more detail in section C.4.a.ii and cost savings are shown in Tables C4, C5, and C6.

3. Benefits to Small Businesses

Businesses, including construction companies, engineers, electricians, parts and components manufacturers, consulting firms, and others involved in designing, installing, and maintaining equipment for both types of technologies may fall into the category of small businesses. The benefits to capture and control and shore power manufacturers and other related business discussed above also apply to small businesses.

4. Benefits to Individuals

The Proposed Regulation would benefit individuals by reducing cancer risk, providing regional health benefits and reducing GHGs, among other benefits. It would do this by reducing emissions from fuel combustion onboard a vessel, which would cut emissions of PM2.5, DPM, NOx, and ROG. GHGs would be reduced when vessels use shore power. For illustrative purposes, CARB staff estimated the reduction in localized cancer risk for three port regions in California under the Proposed Regulation. Staff estimated the statewide value of health benefits from reduced regional NOx and PM2.5 and the value of GHG emissions reductions using the social cost of carbon, as described below.

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[89] California Air Resources Board, Control Measure for Ocean-Going Vessels At Berth Cost Analysis Inputs and Assumptions for Standardized Regulatory Impact Assessment Revised: 5/10/19, Table VIII. Electricity and Fuel Cost Inputs, https://ww3.arb.ca.gov/ports/shorepower/meetings/051419/costassumptions.pdf.

a. Localized Cancer Risk Reduction Benefits

As part of CARB's Preliminary Health Analyses, staff conducted a preliminary risk assessment to estimate the potential cancer health benefits of reducing DPM emitted from diesel-fueled auxiliary engines from vessels operating at berth. [90]

The values reported in CARB's Preliminary Health Analyses were updated in May 2019 to reflect revisions to the tanker vessel implementation schedule from 2025 and 2031 to 2027 and 2029. [91] While the health analysis methodology is the same as described in the Preliminary Health Analyses, the health risks, impacts and valuations reported in this document reflect the May 2019 updates.

In the Preliminary Health Analyses, staff selected three ports to analyze based on port size, vessel activity, emissions, and proximity to disadvantaged communities. Staff selected the Ports of Los Angeles and Long Beach, and combined them in the analysis to represent large ports. The Richmond Complex was selected to represent small ports and tanker marine terminals. POLA and POLB combined represent more than half of the at berth emissions in California while the Richmond Complex represents the second largest emissions for tanker vessels in California. Staff used air dispersion modeling to estimate the DPM concentrations for the communities surrounding the ports and estimated cancer risks from the modeled results. The estimated cancer risks were calculated for the broader population surrounding the ports, as well as the risk to MEIR. Additional information regarding the emissions used, air dispersion modeling, and the methodology for calculating potential cancer risk can be found in the Preliminary Health Analyses.

By 2031, when provisions of the Proposed Regulation would be fully implemented, staff estimate a nearly 60 percent reduction in the statewide DPM emissions from vessels at berth. As a result of the DPM emissions reductions, the potential cancer risk would be significantly reduced in nearby communities. Staff evaluated the percent decrease in potential cancer risk for the population with and without the Proposed Regulation for 2031. Tables B2 and B3 show the estimated population health impacts showing the number of people exposed around POLA, POLB, and Richmond Complex at various potential cancer risk levels. When compared to the Baseline, the Proposed Regulation would provide significant potential cancer risk reductions by reducing the number of people exposed to each of the specified risk levels.

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[90] California Air Resources Board, Preliminary Health Analyses: Control Measure for Ocean-going Vessels At Berth and At Anchor (November 5, 2018), https://ww3.arb.ca.gov/ports/shorepower/meetings/11052018/prelimhealthanalyses.pdf.

[91] California Air Resources Board, Public Workshop to Discuss Draft New At Berth Regulation (May 14, 2019), https://ww3.arb.ca.gov/ports/shorepower/meetings/051419/presentation.pdf.

Table B2: Population Exposed and Elevated Cancer Risk Levels for POLA and POLB Comparing the Baseline and Proposed Regulation in 2031*

Risk Level (chances/million)	Baseline	Proposed Regulation	Reduction in Exposed Population	Percent Decrease
>50	110,000	0	110,000	100%
>30	370,000	6,000	364,000	98%
>20	610,000	95,000	515,000	84%
>10	1,700,000	430,000	1,270,000	74%
>5	3,700,000	1,000,000	2,700,000	72%

*Population-wide cancer risk estimates are based on a 70-year exposure duration using the Risk Management Policy Risk Management Policy (RMP) method (95th/80th percentile daily breathing rates). Fraction of time at home (FAH) equals 1 for all age bins. All numbers are rounded.

Table B3: Population Exposed and Elevated Cancer Risk Levels for the Richmond Complex Comparing the Baseline and Proposed Regulation in 2031*

Risk Level (chances/million)	Baseline	Proposed Regulation	Reduction in Exposed Population	Percent Decrease
>50	0	0	0	0%
>30	0	0	0	0%
>20	80	0	80	100%
>10	2,600	20	2,580	99%
>5	34,000	1,200	32,800	96%

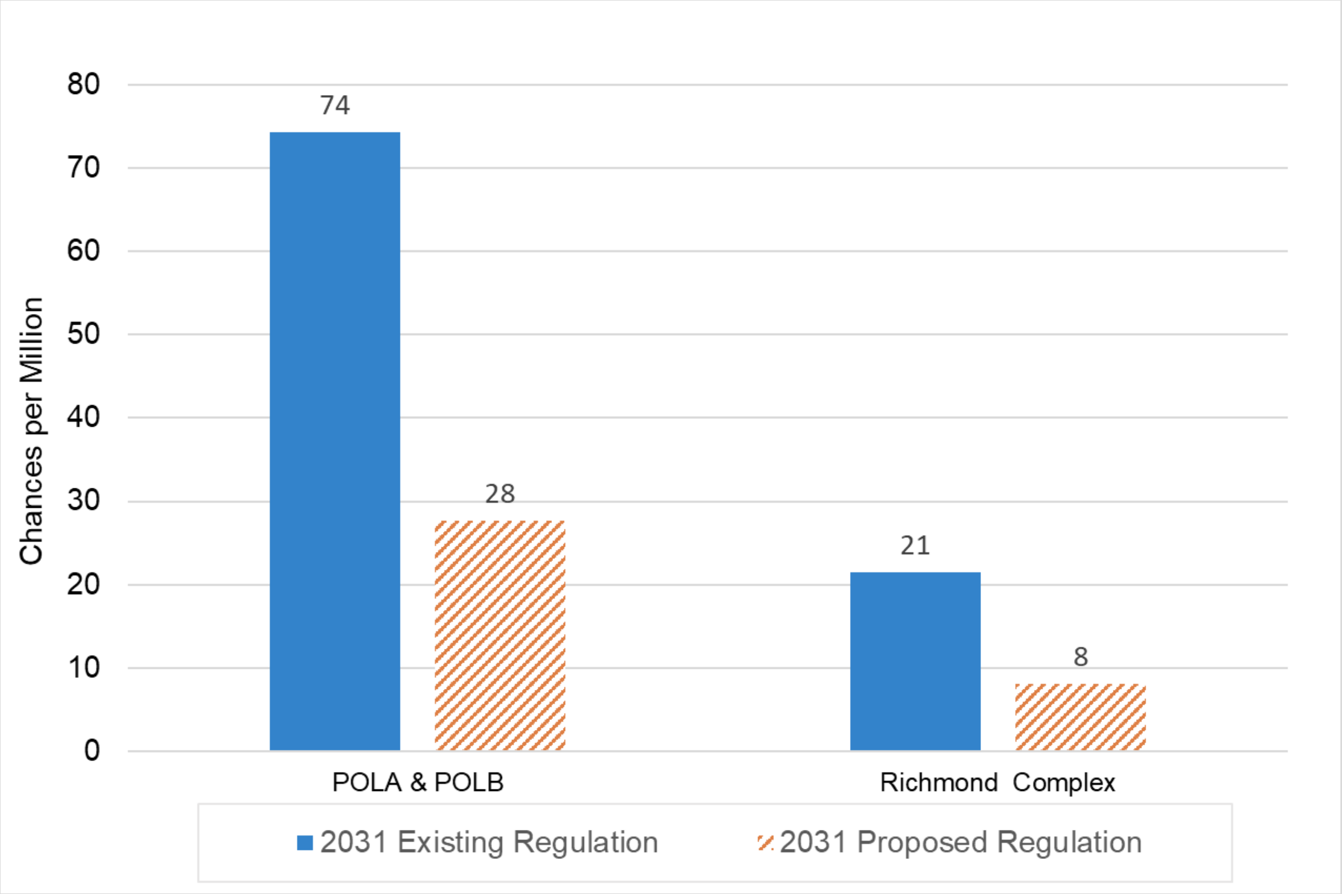
*Population-wide cancer risk estimates are based on a 70-year exposure duration using the RMP method (95th/80th percentile daily breathing rate). FAH equals 1 for all age bins. All numbers are rounded.

For POLA and POLB, the population's exposure to a potential cancer risk level of greater than 30 chances per million would be eliminated with the Proposed Regulation. For the Richmond Complex, the population's exposure to a potential cancer risk level of greater than 20 chances per million would be eliminated by the Proposed Regulation.

In addition to evaluating the population cancer health impacts, staff evaluated the potential cancer risk for the MEIR around POLA and POLB, as well as the MEIR around the Richmond Complex. The MEIR demonstrates the highest exposure at a location where an individual would live. Figure B1 shows that with full implementation of the

Proposed Regulation, the potential cancer risk would be reduced significantly compared to the Baseline.

Figure B1: Maximum Exposed Individual Resident Potential Cancer Risk*



*MEIR cancer risk estimates are based on a 30-year exposure duration using the RMP method (95th/80th percentile daily breathing rate). FAH equals 1 for age bin <16 years, and 0.73 for age bin 16-30 years. All numbers are rounded.

For POLA and POLB, comparing the potential cancer risks with and without the Proposed Regulation in 2031, the MEIR potential cancer risk would decrease from approximately 74 chances per million to approximately 28 chances per million. This represents a reduction in potential cancer risk of more than 60 percent.

Similarly, for the Richmond Complex, comparing the potential cancer risks with and without the Proposed Regulation in 2031, the MEIR potential cancer risk would decrease from approximately 21 chances per million to approximately 8 chances per million. Again, this represents a reduction in potential cancer risk of more than 60 percent.

Based on staff's evaluation for the Proposed Regulation, full implementation would benefit millions of people living next to large ports and tens of thousands of people living next to small ports in California. Although staff's Preliminary Health Analyses only evaluated exposure to receptors and workers off-site of port property, it is expected that significant potential cancer risk reduction would also occur to on-site workers, including, but not limited to longshoremen, crane operators, mechanics, truck drivers, guards, construction workers, and other individuals who work in the ports due to reductions in DPM.

b. Regional Non-Cancer Health Benefits

California experiences some of the highest concentrations of PM2.5 in the nation.[92] Individuals who live in high-risk areas near ports are exposed to higher PM2.5 concentrations from vessels at berth than other California residents. These individuals are at a higher risk of developing respiratory impairments as a result of auxiliary engine and boiler emissions, especially those individuals within sensitive groups, such as those with low socioeconomic standing mentioned above.

The Proposed Regulation would reduce NOx and PM2.5 emissions from vessels operating at berth, resulting in health benefits for individuals in California. Primary PM2.5 is emitted directly from the vessels' auxiliary engines and boilers. Secondary PM2.5 is formed in the atmosphere as a result of chemical reactions. NOx emissions from the vessels' auxiliary engine and boilers are converted by atmospheric processes to secondary ammonium nitrate PM2.5. Reductions in both NOx and primary PM2.5 emissions from the Proposed Regulation would result in a greater reduction in PM2.5 exposure to the community. Benefits from the reductions include fewer hospital and emergency room visits and avoided premature deaths.

CARB staff used two methods to estimate the health benefits of the Proposed Regulation. For regions where air dispersion modeling had been performed (South Coast Air Basin), health benefits were estimated using the results from air dispersion modeling. For all other air basins where basin-wide air dispersion results were unavailable, staff used the incidence per ton (IPT) methodology, described in Appendix G. The two methodologies are summarized in the following sections.

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[92] United States Environmental Protection Agency, Fine Particle Concentrations Based on Monitored Air Quality From 2009 – 2011 (2013), http://www.epa.gov/pm/2012/20092011table.pdf.

i. Direct Estimation of Health Outcomes from Air Dispersion Modeling

For the South Coast Air Basin, CARB staff used air dispersion modeling to estimate the changes in primary PM2.5 concentrations resulting from the regulation over a gridded modeling domain covering portions of Los Angeles and Orange Counties surrounding POLA and POLB. The modeling approach is described in the Preliminary Health Analyses. Using a methodology developed by U.S. EPA,[93] CARB staff used a health model to estimate the impacts of the estimated PM2.5 concentrations in each modeled grid cell, and results were aggregated over the domain.

ii. Incidents-Per-Ton Methodology

The IPT methodology is based on a methodology similar to one developed by U.S. EPA.[94,95,96] The methodology is used to estimate the benefits of reducing both primary PM2.5 emitted directly from sources, and secondary PM2.5 formed from precursors by chemical processes in the atmosphere, when modeled concentrations are not available.

The basis of the IPT methodology is that changes in emissions are approximately proportional to changes in health outcomes such as cardiopulmonary mortality, hospitalizations for cardiovascular illness, hospitalizations for respiratory illness, and emergency room visits. The IPT process begins by calculating IPT factors for each air basin. This is accomplished by adding up the estimated number of each of the health outcomes associated with exposure to interpolated PM2.5 concentrations for 2014-2016 baseline period, then dividing the total number of health outcome by the annual emissions of PM2.5 plus all precursors. The calculation is performed separately for each air basin. Air quality data were extracted from CARB's ADAM air Quality database.[97]

Once the IPT factors have been calculated for each air basin, the reductions in health outcomes are calculated by multiplying the emissions reductions that are expected from the regulation, in each air basin, by the IPT factor for that basin. This yields an estimate of the reduction in health outcomes achieved by the regulation. For future years, the

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[93] United States Environmental Protection Agency, Environmental Benefits Mapping and Analysis Program: Community Edition (BenMAP-CE) User Manual and Appendices (2017), Research Triangle Park, NC, www.epa.gov/benmap.

[94] Fann N, Fulcher CM, Hubbell BJ., The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution (2009), Air Quality. Atmosphere & Health. 2:169-176, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770129/.

[95] Fann N, Baker KR, Fulcher CM., Characterizing the PM2.5-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S. Environ Int. (2012 Nov 15); 49:141-51, https://www.sciencedirect.com/science/article/pii/S0160412012001985.

[96] Fann N, Baker K, Chan E, Eyth A, Macpherson A, Miller E, Snyder J., Assessing Human Health PM2.5 and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025 (2018), Environ. Sci. Technol. 52 (15), pp 8095–8103, https://pubs.acs.org/doi/abs/10.1021/acs.est.8b02050.

[97] California Air Resources Board, iADAM: Air Quality Data Statistics database, https://www.arb.ca.gov/adam/

number of outcomes is adjusted to account for population growth. The methodology is described in detail in Appendix G.

iii. Results

The largest estimated health benefits correspond to regions in California with the most vessel visits, which are the South Coast Air Basin and the San Francisco Bay Air Basin. Table B4 shows the estimated avoided premature deaths, avoided hospital admissions and avoided emergency room visits that would result from the Proposed Regulation, summed over the years 2021 through 2032 by California air basin, relative to the Baseline. Staff used the range of years from 2021-2032 rather than the 2020-2032 period evaluated in the cost analysis because there would be no emissions reductions or associated health benefits prior to the first control requirement in 2021. Values in parenthesis represent the 95 percent confidence intervals around the estimated mean, which is the range of values that would be 95 percent certain to contain the true mean value. As detailed in Chapter B.1.b., the Proposed Regulation is estimated to reduce overall emissions of PM2.5 and NOx in all years, and lead to a net reduction in adverse health outcomes statewide, relative to the Baseline.

Table B4: Regional and Statewide Avoided Premature Deaths, Hospital Admissions and Emergency Room Visits from 2021 to 2032 under the Proposed Regulation for Total PM2.5 and NOx

Air Basin	Avoided Cardiopulmonary Mortality	Avoided Hospital Admissions	Avoided Emergency Room Visits
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
San Diego County	7 (6 - 9)	2 (0 - 4)	3 (2 - 4)
San Francisco Bay	34 (26 - 42)	11 (1 - 20)	19 (12 - 26)
San Joaquin Valley	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
South Central Coast	2 (1 - 2)	1 (0 - 1)	1 (1 - 1)
South Coast	227 (178 - 278)	75 (10 - 138)	116 (74 - 159)
Statewide Total*	271 (212 - 331)	88 (11 - 163)	140 (88 - 191)

*May not sum to totals due to rounding.

In general, health studies have shown that populations with low income are more susceptible to health problems from exposure to air pollution.[98,99] However, the

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[98] Daniel Krewski et al., Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality (May 2009), Health Effects Institute Research Report 140, https://ephtracking.cdc.gov/docs/RR140-Krewski.pdf.

[99] R. Charon Gwynn et al., The burden of air pollution: impacts among racial minorities (Aug. 2001), Environmental Health Perspectives; 109(4):501–6, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240572/.

methods currently used by U.S. EPA and CARB do not have the granularity to account for this impact.

In accordance with U.S. EPA practice, health outcomes were monetized by multiplying incidence by a standard value derived from economic studies.[100] The valuation per incident is provided in Table B5. The valuation for avoided premature mortality is based on willingness to pay to avoid premature mortality.[101] This value is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risks of dying in a year. This is not an estimate of how much any single individual would be willing to pay to prevent a certain death of any particular person,[102] nor does it consider any specific costs associated with mortality such as hospital expenditures. While reductions in premature mortality are an important benefit of the Proposed Regulation, the valuation methods used to monetize the benefit do not easily lend themselves to macroeconomic modeling. The monetized benefits associated with avoided premature deaths are reported here, but are not included in macroeconomic modeling (Chapter E).

Unlike premature mortality valuation, the valuation for avoided hospitalizations and Emergency Room (ER) visits are based on a combination of typical costs associated with hospitalization and the willingness of surveyed individuals to pay to avoid adverse outcomes that occur when hospitalized. These include hospital charges, post-hospitalization medical care, out-of-pocket expenses, and lost earnings for both individuals and family members, lost recreation value, and lost household protection (e.g., valuation of time-losses from inability to maintain the household or provide childcare).[103] Because these are most closely associated with specific cost-savings to individuals (and costs to the healthcare system), monetized benefits from avoided hospitalizations and ER visits are included in macroeconomic modeling (Chapter E).

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[100] National Center for Environmental Economics et al., Appendix B: Mortality Risk Valuation Estimates, Guidelines for Preparing Economic Analyses (EPA 240-R-10-001, Dec. 2010) https://www.epa.gov/sites/production/files/2017-09/documents/ee-0568-22.pdf.

[101] United States Environmental Protection Agency Science Advisory Board (U.S. EPA-SAB), An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction (EPA-SAB-EEAC-00-013, July 2000), http://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf.

[102] United States Environmental Protection Agency, Mortality Risk Valuation – What does it mean the place a value on a life?, https://www.epa.gov/environmental-economics/mortality-risk-valuation#means (last visited Aug. 14, 2018).

[103] Lauraine G. Chestnut et. al., The Economic Value Of Preventing Respiratory And Cardiovascular Hospitalizations (Contemporary Economic Policy, 24: 127–143. doi: 10.1093/CEP/BYJ007, Jan. 2006), http://onlinelibrary.wiley.com/doi/10.1093/cep/byj007/full.

Table B5: Valuation Per Incident for Avoided Health Outcomes

Outcome	Cost-Savings per Incident (2019$)
Avoided Premature Deaths	$9,744,000
Avoided Cardiovascular Hospitalizations	$59,000
Avoided Acute Respiratory Hospitalizations	$51,000
Avoided ER Department Visits	$840

Statewide valuation of health benefits were calculated by multiplying the avoided health outcomes by valuation per incident. The total statewide valuation due to avoided health outcomes between 2021 and 2032, which totaled $2.64 billion. These values are summarized in Table B6. The spatial distribution of these benefits follow the distribution of emissions reductions and avoided adverse health outcomes, therefore most cost savings to individuals would occur in the South Coast and San Francisco air basins.

Table B6: Statewide Valuation from Avoided Adverse Health Outcomes between 2021 and 2032 as a Result of the Proposed Regulation

Outcome	Cost-Savings (2019$)
Avoided Premature Deaths	$2,639,804,000
Avoided Hospitalizations	$4,800,000
Avoided ER Visits	$117,000
Total Cost-Savings	$2,644,720,000 ($2.64 billion)

c. GHG Emissions Benefits

As described in Chapter B.1.b., the Proposed Regulation would result in an estimated cumulative net reduction in GHG emissions between 2021 and 2032 totaling 400,000 metric tons compared with the Baseline.

The monetary value of these GHG reductions can be estimated using the social cost of carbon (SC-CO_2), which provides a dollar valuation of the damages caused by one ton of carbon pollution and represents the monetary benefit today of reducing carbon emissions in the future.

The Council of Economic Advisors and the Office of Management and Budget convened an Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) to develop a methodology for estimating the social cost of carbon (SC-CO2). This methodology relied on a standardized range of assumptions and could be used consistently when estimating the benefits of regulations across agencies and around the world.[104]

In this analysis, CARB utilized the current IWG supported SC-CO_2 values to consider the social costs of actions to reduce GHG emissions. This is consistent with the approach presented in the Revised 2017 Climate Change Scoping Plan[105] and is in line with Executive Orders including 12866 and the Office of Management and Budget Circular A-4 of September 17, 2003. It reflects the best available science in the estimation of the socio-economic impacts of carbon.[106]

The IWG describes the social costs of carbon as follows:

> *The social cost of carbon (SC-CO_2) for a given year is an estimate, in dollars, of the present discounted value of the future damage caused by a 1-metric ton increase in carbon dioxide (CO_2) emissions into the atmosphere in that year, or equivalently, the benefits of reducing CO_2 emissions by the same amount in that year. The SC-CO_2 is intended to provide a comprehensive measure of the net damages – that is, the monetized value of the net impacts- from global climate change that result from an additional ton of CO_2.*
>
> *These damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. Many of these damages from CO_2 emissions today will affect economic outcomes throughout the next several centuries.*[107]

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[104] Additional technical detail on the IWG process is available in the Technical Updates of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866 (by the Interagency Working Group on Social Cost of Greenhouse Gases, United States Government). Iterations of the Updates are https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf, and https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf.

[105] California Air Resources Board, The Revised 2017 Climate Change Scoping Plan (October 27, 2017), https://www.arb.ca.gov/cc/scopingplan/revised2017spu.pdf, (last accessed Oct. 30, 2017).

[106] Office of Management and Budget, Circular A-4 (Sept. 2003), https://www.transportation.gov/sites/dot.gov/files/docs/OMB%20Circular%20No.%20A-4.pdf.

[107] The National Academies of Sciences, Engineering, Medicine, Valuing Climate Damages: Updating Estimation of Carbon Dioxide (2017), The National Academies Press (Washington DC), http://www.nap.edu/24651, (last accessed Nov. 14, 2017).

The SC-CO_2 is year specific, and is highly sensitive to the discount rate used to discount the value of the damages in the future due to CO_2. The SC-CO_2 increases over time as systems become more stressed from the aggregate impacts of climate change and future emissions cause incrementally larger damages. A higher discount rate decreases the value today of future environmental damages. This analysis uses the IWG standardized range of discount rates from 2.5 to 5 percent to represent varying valuation of future damages. Table B7 presents the range of IWG SC-CO_2 values by year.[108]

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[108] The SC-CO_2 values are of July 2015 and are available at: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866 (Revised July 2015), https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.

Table B7: SC-CO_2, 2021-2032 (in 2007$ per Metric Ton)

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2021	$12	$42	$63
2022	$13	$43	$64
2023	$13	$44	$65
2024	$13	$45	$66
2025	$14	$46	$68
2026	$14	$47	$69
2027	$15	$48	$70
2028	$15	$49	$71
2029	$15	$49	$72
2030	$16	$50	$73
2031	$16	$51	$74
2032	$17	$52	$75

As there is no social cost of CO_2e or GHG estimate, there is not a straightforward metric to estimate the GHG benefits of the Proposed Regulation. For the auxiliary engines and boilers operating on vessels at berth, CO2 accounts or more than 99 percent of the GHG emissions per each kilowatt of energy produced, as shown in Appendix 2 of the 2018/2019 draft Inventory Methodology. If all GHG emissions reductions under the Proposed Regulation are assumed to be CO2 reductions, the SC-CO_2 from 2021 through 2032 is the sum of the annual GHG emissions reductions multiplied by the SC-CO_2 in each year. The estimated benefits from the Proposed Regulation from 2021 through 2032 are estimated to range from $2.84 million to $28.7 million (in 2019$) relative to the baseline.[109]

It is important to note that the SC-CO_2, while intended to be a comprehensive estimate of the damage caused by carbon globally, does not represent the cumulative cost of climate change and air pollution to society. There are additional costs to society outside of the SC-CO_2, including costs associated with changes in co-pollutants, the social cost of other GHGs, including methane and nitrous oxide, and costs that cannot be included due to modeling and data limitations. The Intergovernmental Panel on Climate Change (IPCC) has stated that the IWG SC-CO_2 estimates are likely underestimated due to the

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[109] Staff adjusted the social cost of CO2 in 2007 dollars to 2018 dollars by using the Bureau of Labor Statistics Consumer Price Index (CPI) calculator, adjusting from January 2007 dollars to January 2018 dollars: https://www.bls.gov/data/inflation_calculator.htm.

omission of significant impacts that cannot be accurately monetized, including important physical, ecological, and economic impacts.

d. Unquantified Benefits

Under the Proposed Regulation, NOx emissions reductions would occur, which as described above, are essential to cutting regional ozone levels to attain federal and State ambient air quality standards. The reduction in PM2.5 that would result from the Proposed Regulation would also likely result in better visibility throughout regions near ports due to the improved air quality, which is an unquantified benefit to individuals in California.

C. DIRECT COSTS

Multiple parties would incur direct costs under the Proposed Regulation. This includes port authorities, terminal operators, and vessel operators. State, local, and federal agencies would also incur costs to review and permit infrastructure projects and emission control technologies associated with the Proposed Regulation.

1. Directly Regulated Parties: Ports, Terminal and Vessel Operators

Port authorities are local government entities and are either landlord ports (typically large ports like Los Angeles and Long Beach)[110,111] or operating ports (smaller ports like Hueneme or Stockton).[112] Landlord ports lease space to terminal operators who then contract directly with shipping lines to do business and handle the daily operations at their terminals.[113] Operating ports are directly involved in day-to-day operational decisions at their berths.

Terminal and vessel operators are typically public companies that are investor owned. This chapter describes direct costs that would be incurred by ports, terminal and vessel operators, and public agencies. Chapter D discusses the fiscal impact on State government and local government (including ports).

The costs to directly regulated parties may include one-time equipment capital and installation costs and recurring costs for maintenance, labor, air pollution control services (rental of capture and control barge-based systems), fuel, electricity, and administrative costs, depending on the emission control strategy used for compliance. The cost estimates provided are based on the three different compliance pathways terminal and vessel operators would be most likely to employ. The three pathways are: (1) connection to shore power (grid-based electricity provided by the local utility company); (2) the use of barge-based capture and control systems; and (3) the use of land-based capture and control systems. Staff expects that the compliance pathway chosen would depend on the terminal location and vessel type, as further discussed in this chapter.

2. Other Parties Incurring Costs

The costs to state, local and federal agencies for project reviews and permitting are described in Chapter D, Fiscal Impacts.

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[110] Port of Los Angeles, Port 101, https://www.portoflosangeles.org/about/port-101 (last accessed July 2019).

[111] Port of Long Beach, FAQs - Does the Port receive funding from the City of Long Beach?, http://www.polb.com/about/faqs.asp#530 (last accessed July 2019).

[112] Janice Hoppe-Spiers, Transportation and Logistics International, Port of Stockton, http://www.tlimagazine.com/sections/shipping-and-ports/2359-port-of-stockton.

[113] Port of Long Beach, FAQs - Does the Port receive funding from the City of Long Beach?, http://www.polb.com/about/faqs.asp#530 (last accessed July 2019).

3. Scope of Cost Analysis

a. Cost Analysis Baseline

The final requirements under the Existing Regulation take effect in 2020. Therefore, the baseline for the cost analysis is full implementation of the Existing Regulation, and costs calculated for the Proposed Regulation are incremental to the baseline.

b. Cost Analysis Timeline

Staff assumes that costs incurred by the regulated parties and CARB would start in 2020, one year prior to the first implementation date through 2032 when the Proposed Regulation would be fully implemented.

The anticipated timing of when each cost would begin is summarized in Table C1.

Table C1: Timing of Costs

Year	Costs Beginning in Year
2020	• CARB Personnel-Years (PYs) for technology approvals and associated activities. • Container/Reefer and Cruise terminal shore power equipment capital costs. • Administrative costs for development of Port Plans and Terminal Plans for all ports and all vessel categories. • Feasibility study, engineering and permitting costs for infrastructure projects to support land-based capture and control systems at Tanker terminals (POLA/POLB).
2021	• Control requirements for Container, Reefer, and Cruise vessels begin. • CARB PYs for enforcement and state, local, and federal agency PYs for infrastructure permitting. • Container/Reefer and Cruise vessel shore power labor and energy costs. • Container/Reefer and Cruise terminal shore power equipment maintenance costs. • Container/Reefer vessel barge-based capture and control system hourly usage costs. • Administrative costs for reporting of Container/Reefer and Cruise vessel visits by terminal operators and vessel operators. • Remediation costs for applicable Container/Reefer and Cruise vessel visits.

2022	• Feasibility study, engineering and permitting costs for infrastructure projects to support land-based capture and control systems at all other Tanker terminals (all other tanker terminals over the terminal threshold statewide).
2023	• Administrative costs for updating Terminal Plans for Ro-Ro terminals.
2024	• Ro-Ro terminal land-based capture and control system capital costs. • Tanker terminal land-based capture and control system capital costs (POLA/POLB).
2025	• Control requirements for Ro-Ro vessels begin. • Ro-Ro terminal barge-based capture and control system hourly usage costs. • Ro-Ro terminal land-based capture and control system operating, maintenance, and performance testing costs. • Administrative costs for reporting of Ro-Ro vessel visits by terminal operators and vessel operators. • Administrative costs for updating Terminal Plans for Tanker terminals (POLA/POLB). • Remediation costs for applicable Ro-Ro vessel visits.
2026	• Tanker terminal land-based capture and control system capital costs (all other Tanker terminals over the terminal threshold statewide).
2027	• Control requirements for tanker vessels at POLA/POLB begin. • Tanker terminal land-based capture and control equipment operating, labor and maintenance costs (POLA/POLB). • Administrative costs for reporting of Tanker vessel visits by terminal operators and vessel operators (POLA/POLB). • Remediation costs for applicable Tanker vessel visits (POLA/POLB).
2028	• Administrative costs for updating Terminal Plans for all other Tanker terminals (all other Tanker terminals over the terminal threshold statewide).
2029	• Control requirements for tanker vessels at all other terminals. • Tanker terminal land-based capture and control equipment operating, labor, maintenance and performance testing costs (all other Tanker terminals over the terminal threshold statewide). • Administrative costs for reporting of Tanker vessel visits by terminal operators and vessel operators (all other terminals over the terminal threshold statewide). • Remediation fee costs for applicable Tanker vessel visits (all other terminals over the terminal threshold statewide).

c. Identification of Affected Regulated Parties

Staff identified the ports, terminals, and number of vessels that would incur costs under the Proposed Regulation by comparing the port and terminal thresholds for annual vessel visits in the Proposed Regulation with the number of vessel visits that occurred at each terminal in 2017.[114] The locations that exceeded the threshold for vessel visits are included in the CARB Staff Analysis of Potential Emission Reduction Strategies by Port/Terminal/Berth (Berth Analysis), which is provided as Appendix C to the SRIA and further described in this chapter. The Berth Analysis identifies all of the ports, terminals and berths that staff anticipate would be affected by the Proposed Regulation upon initial implementation, and the compliance method and associated infrastructure that staff anticipate would be required at each individual location. Vessel activity and cargo volume are expected to grow. As detailed in the 2018/2019 draft Inventory Methodology, vessel size and cargo capacity are expected to increase in future years. Staff anticipate that the increase in activity and cargo growth will be primarily accommodated by larger vessels and not by an increase in vessel visits from smaller vessels. Therefore, staff do not expect any ports or marine terminals in addition to those identified in the Berth Analysis to exceed the vessel visit thresholds from 2021-2032. The Berth Analysis provides the basis for the following key assumptions for the cost analysis, which are explained in further detail in Appendix A, Cost Analysis Inputs and Assumptions:

- Locations and numbers of affected terminals and berths (see Appendix A, Table XI; Appendix B, “Berths, Terminals, Vessels”)

- Locations and numbers of barge-based capture and control systems (see Appendix A, Table XI; Appendix B, “Berths, Terminals, Vessels”)

- Locations and numbers of land-based capture and control systems (see Appendix A, Table XI; Appendix B, “Berths, Terminals, Vessels”)

- Number of unique vessels that would require shore power retrofits (see Appendix A, Table XI; Appendix B, “Berths, Terminals, Vessels”)

- Locations and numbers of shore power infrastructure projects (see Appendix A, Table XI; Appendix B, “SP Berth Retrofit”)

- Locations and numbers of newly regulated vessel visits (see Appendix A, Tables XIII-A through XIII-D; Appendix B, “Vessel Visits”)

From the above information, staff further refined the anticipated number of vessel visits that would install either shore power or utilize a capture and control system by adjusting the newly regulated vessel visits (for container, reefer and cruise vessels) or the total

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[114] California State Lands Commission, *CARB2017,* April 2018

vessel visits (for currently unregulated vessel types) by the anticipated number of TIEs, VIEs, exceptions, and remediation fee visits that staff anticipate would occur based on the Proposed Regulation requirements and past enforcement data; see Appendix A, Tables XIII-A through XIII-D for details. Staff then used the adjusted number of vessel visits to estimate hourly fees for barge-based capture and control units, capture and control labor and operating costs, and shore power labor and energy costs and cost savings, as further described below.

d. Key Analysis-wide Assumptions

i. Annualization of Costs Based on Equipment Lifespan

Staff assumed that capital costs (including construction and installation) for shore power and capture and control systems and associated infrastructure would be annualized over the expected equipment lifespan. Staff assumed a 20-year life for terminal equipment and a 10-year life for vessel equipment based on feedback provided by multiple terminal operators and vessel operators, as described in Appendix A, Table XII, Appendix B, “SP Berth Retrofit”. Where vessel equipment would reach the end of its operational life prior to 2023, staff assumed that in subsequent years, capital costs would continue to be incurred to conduct major repairs and component replacements at a rate of 50 percent of the calculated annualized cost based on discussions with vessel operators.

ii. Application of Annual Industry Growth Factors

The growth factors represent growth in cargo movement, and staff assumes that the growth in costs resulting from the Proposed Regulation would be directly proportional to projected growth in cargo movement. To the extent that an increase in cargo movement would affect the various regulatory costs that would be incurred under the Proposed Regulation would depend on a number of factors, including but not limited to: whether or not vessel visits increase over time, or vessel sizes get larger and vessel visits remain constant or decrease; whether the average vessel visit durations change; and whether additional infrastructure is needed to accommodate growth, and resulting maintenance costs increase due to increased utilization of equipment. To account for an increase in costs that would cover the analysis period due to growth in cargo movement, and in consideration of the uncertainty of all of the above variables, staff applied the growth factors to all costs, rather than increasing any of the individual activity inputs such as number of vessel visits over the analysis period.

The cost analysis equations are provided in Appendix E, which also shows to which costs staff applied growth factors. The growth factors used for the cost analysis are based on the same growth factors used to develop the emissions estimates. The source of the growth factors is the FAF, except where port-specific growth factors were used, as described in Chapter A.6.

For the cost analysis, staff aggregated the regional FAF or port-specific growth factors, weighted by number of vessel visits, to produce single annual statewide growth factors for each vessel type for each year and then were compounded for each year of the analysis period. The aggregated and compounded annual growth factors used in the cost analysis are provided in Table C2.

Table C2: Annual Industry Growth Factors

Year	Container/Reefer	Cruise	Ro-Ro	Tanker
2019	8.0%	7.5%	7.5%	1.0%
2020	15.3%	16.0%	11.5%	1.5%
2021	19.4%	20.2%	15.1%	2.7%
2022	23.8%	24.7%	18.4%	3.5%
2023	28.5%	29.2%	21.9%	4.3%
2024	33.4%	34.0%	25.4%	5.1%
2025	41.0%	38.9%	29.1%	5.9%
2026	44.4%	44.0%	32.9%	7.1%
2027	48.2%	49.3%	35.9%	8.2%
2028	52.3%	54.8%	39.0%	9.4%
2029	56.7%	60.5%	42.2%	10.5%
2030	61.4%	66.5%	45.4%	11.7%
2031	69.1%	72.6%	48.9%	13.0%
2032	77.2%	78.9%	52.3%	14.3%

4. Direct Cost Inputs

Table C3 summarizes the anticipated control strategies, which vessel types staff assumes they would apply to, and parties expected to incur costs resulting from the use of each control strategy. A detailed analysis of which emission control strategies staff anticipate would be used at each port, terminal and berth is provided in the Berth Analysis.

Table C3: Assumed Emission Control Strategies by Vessel Type and Responsible Party

Emission Control Strategy	Vessel Types Anticipated to Use Strategy	Parties Anticipated to Incur Costs
Shore Power	Container/Reefer Cruise	Ports Terminal Operators Vessel Operators CARB
Land-Based Capture and Control	Ro-Ro Tankers	Ports Terminal Operators Vessel Operators CARB Other State, Local and Federal Agencies
Barge-Based Capture and Control	Container/Reefer Ro-Ro	Vessel Operators CARB

a. Shore Power Costs

i. Summary of Annualized Costs

Table C4 and C5 summarize annualized costs and savings staff assumes would be incurred by ports and terminal operators for use of shore power as a result of the Proposed Regulation. Table C6 summarizes annualized costs for vessel operators. Each of these costs are further described following the tables.

Table C4: Shore Power Costs and Savings Incurred by Ports Between 2020 and 2032

Year	Terminal Equipment Capital Costs*	Terminal Equipment Maintenance Costs	Equipment Operating Labor Costs	Shore Power Energy Costs	LCFS Credits	Total (Net) Costs
2020	$8,659,000	$0	$0	$0	$0	$8,659,000
2021	$8,977,000	$60,000	$218,000	$0	$0	$9,255,000
2022	$9,307,000	$62,000	$226,000	$0	$0	$9,596,000
2023	$9,651,000	$65,000	$235,000	$272,000	-$163,000	$10,059,000
2024	$10,008,000	$67,000	$244,000	$284,000	-$168,000	$10,435,000
2025	$10,398,000	$69,000	$256,000	$304,000	-$169,000	$10,858,000
2026	$10,766,000	$72,000	$263,000	$310,000	-$175,000	$11,237,000
2027	$11,150,000	$75,000	$271,000	$319,000	-$182,000	$11,634,000
2028	$11,550,000	$77,000	$279,000	$330,000	-$189,000	$12,047,000
2029	$11,965,000	$80,000	$288,000	$344,000	-$197,000	$12,480,000
2030	$12,397,000	$83,000	$297,000	$358,000	-$205,000	$12,930,000
2031	$12,867,000	$86,000	$310,000	$377,000	-$219,000	$13,422,000
2032	$13,356,000	$89,000	$324,000	$397,000	-$233,000	$13,933,000
Total	$141,050,000	$887,000	$3,211,000	$3,296,000	-$1,899,000	$146,545,000

*Includes capital costs for berth retrofits and shore power vault installations. The assumed number of berth retrofits and shore power vault installations are described in Appendix A, Table XI, Appendix B, “SP Berth Retrofit”.

Table C5: Shore Power Costs and Savings Incurred by Terminal Operators

Year	Labor Costs	Shore Power Energy Costs	LCFS Credits	Total (Net) Costs
2020	$0	$0	$0	$0
2021	$506,000	$630,000	-$226,000	$910,000
2022	$525,000	$650,000	-$232,000	$942,000
2023	$545,000	$1,118,000	-$333,000	$1,330,000
2024	$566,000	$1,161,000	-$343,000	$1,384,000
2025	$595,000	$1,209,000	-$338,000	$1,467,000
2026	$611,000	$1,253,000	-$354,000	$1,510,000
2027	$629,000	$1,301,000	-$371,000	$1,558,000
2028	$647,000	$1,352,000	-$389,000	$1,610,000
2029	$667,000	$1,408,000	-$409,000	$1,667,000
2030	$688,000	$1,467,000	-$428,000	$1,727,000
2031	$719,000	$1,524,000	-$452,000	$1,791,000
2032	$752,000	$1,583,000	-$478,000	$1,857,000
Total	$7,451,000	$14,655,000	-$4,354,000	$17,752,000

Table C6: Shore Power Costs and Savings Incurred by Vessel Operators

Year	Vessel Equipment Capital Costs	Vessel Equipment Maintenance Costs	Fuel Cost Savings	Total (Net) Costs
2020	$12,900,000	$0	$0	$12,900,000
2021	$13,837,000	$958,000	-$546,000	$14,250,000
2022	$14,339,000	$993,000	-$589,000	$14,743,000
2023	$14,867,000	$1,030,000	-$1,319,000	$14,578,000
2024	$15,423,000	$1,068,000	-$1,437,000	$15,054,000
2025	$16,006,000	$1,109,000	-$1,554,000	$15,561,000
2026	$16,768,000	$1,165,000	-$1,646,000	$16,287,000
2027	$17,271,000	$1,198,000	-$1,758,000	$16,711,000
2028	$17,807,000	$1,233,000	-$1,881,000	$17,158,000
2029	$18,373,000	$1,271,000	-$2,016,000	$17,628,000
2030	$18,971,000	$1,311,000	-$2,145,000	$18,137,000
2031	$19,601,000	$1,353,000	-$2,312,000	$18,642,000
2032	$20,437,000	$1,413,000	-$2,470,000	$19,380,000
Total	$216,601,000	$14,101,000	-$19,672,000	$211,030,000

ii. **Description of Costs for Shore Power**

For vessels using shore power to comply, vessels would shut off their diesel powered generators and connect to land-based electricity provided by the local electric utility. Shore power is already used as the primary compliance pathway for container, reefer and cruise vessel fleets under the Existing Regulation. The Proposed Regulation would primarily result in additional use of shore power at terminals where shore power is already installed.

<u>Terminal Shore Power Infrastructure</u>

The ports and terminals that receive container, reefer and cruise vessels have already made significant capital investments to facilitate use of shore power to comply with the Existing Regulation.

As described in the Berth Analysis and summarized in Appendix A, Table XI, and Appendix B, “SP Berth Retrofit”, staff anticipate that only one cruise vessel berth statewide, at the Port of San Francisco, may need to be retrofit to provide shore power where none currently exist. Staff do not anticipate that any container and reefer terminals would need to install shore power where none currently exist; however, staff assumes that five additional shore power vaults would need to be installed at container and reefer terminals that are already shore power capable, to accommodate larger vessels and/or varying berthing positions for a larger percentage of vessel visits.

To estimate costs for shore power terminal infrastructure, staff relied primarily on data from surveys of ports conducted in April 2018. The survey respondents reported a wide range of shore power berth retrofit costs, varying by individual project and by vessel type. However, because staff understands that a cruise berth at the Port of San Francisco is the only berth that would require a shore power infrastructure project where none currently exists, staff used the Port of San Francisco’s own cost estimate of approximately $82 million to retrofit the berth and install associated infrastructure, as described in Appendix A, Table XII, Appendix B, “SP Berth Retrofit”.

Many tanker terminals, particularly those located within the San Francisco Bay such as the Richmond Long Wharf, are located off-shore, and would require more extensive infrastructure projects to become shore power-capable, compared with tanker terminals located within ports. Regardless, staff conversations with tanker terminal operators indicated that due to reasons including the difficulty of equipping a global fleet of tanker vessels with shore power equipment, tanker vessels would likely use capture and control options at all terminals statewide where emissions control would be required. Therefore, the cost analysis for the Proposed Regulation does not assume any shore power for tanker vessels.

The cost analysis for the Proposed Regulation also does not assume any shore power for ro-ro vessels. Staff’s assumptions regarding anticipated technology at each ro-ro terminal and berth are stated in the Berth Analysis. Reasons that Staff believe vessels and terminals would not utilize shore power include: the high number of vessels that are infrequent visitors to California ports compared to container and reefer vessels; the tendency for ro-ro vessels to visit multiple California berths in a single voyage requiring consistent emission control strategy; and the short duration of ro-ro visits compared with the length of time it takes to connect vessels to shore power. For vessels that visit California infrequently, installing shore power equipment is not financially viable.

Vessel Shore Power Equipment

Container, reefer, and cruise vessel operators have also made significant capital investments to facilitate use of shore power to comply with the Existing Regulation, with 485 vessels already equipped that have visited California ports.

Staff assumes that 57 container and reefer vessels and 26 cruise vessels would install shore power equipment to comply with the Proposed Regulation. Staff based these estimates on the unique vessels that visited California ports in 2017.[115] To produce these estimates, staff first identified which vessels visited which ports, removed the vessels that are already shore power capable, and then reduced the remaining number of vessels to account for vessels that staff assumes would install shore power to comply with the 2020 requirements of the Existing Regulation. This is based on the following assumptions:

Container/Reefer Vessels

- “Frequent vessels,” defined as vessels that visited any California location in 2017 four or more times, would most likely install shore power due to the Existing Regulation. CARB staff assumes that vessels making four or more visits would need to retrofit for shore power in order to meet the fleet percentage compliance requirements of the Existing Regulation in 2020.

- Infrequent vessels that are not shore power capable would most likely install shore power due to the Proposed Regulation if they visited the Port of Oakland one or more times in 2017. This is because shore power is expected to be the only compliance option at the Port of Oakland as described in the Berth Analysis. Infrequent vessels that visited POLA and/or POLB three or more times in 2017 would most likely install shore power because barge-based capture and control systems are expected to be available at POLA and POLB.

- Infrequent, non shore power capable vessels that do not meet the above criteria would most likely use capture and control systems or TIEs/VIEs to comply with the Proposed Regulation.

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[115] California State Lands Commission, *CARB2017,* April 2018.

Cruise Vessels

- All cruise vessels covered under the Proposed Regulation would install shore power, if they are not already shore powered equipped. This assumption is based on shore power being the only anticipated compliance pathway for cruise vessels, primarily due to aesthetics and passenger safety.

Vessel operators would incur capital costs to install shore power equipment on vessels. This equipment includes a cable management system, switchgear, synchronizing switch, and potentially a voltage transformer. To gather current information on these costs, staff conducted surveys of vessel operators in June 2018.

Based on the survey results, capital costs to equip or retrofit a vessel for shore power varied widely depending on vessel type and within each vessel type. Therefore, staff calculated an average capital cost for each vessel type as specified in Appendix A, Table XII, "SP Vessel Retrofit". The extensive range in the reported survey data likely occurred for various reasons, including whether the vessel was a new build or retrofit, the size and age of the vessel, and some respondents factoring in different costs than others.

Staff assumes that vessel operators would begin to incur annualized capital costs to retrofit vessels for shore power one year prior to the implementation date for that vessel type, as described in Appendix A, Table I.

Shore Power Electricity Costs

Electricity costs would result from the use of shore power. These costs are typically directly incurred by the port or terminal operator, then passed along to the vessel operator.

To estimate the electricity cost, staff surveyed several ports on the cost of electricity specifically provided for shore power, taking into account demand charges and other factors. In some cases, CARB staff analyzed terminal electricity bills provided by the ports to determine the $/kilowatt-hour rate. CARB staff found costs to range from about 15 to 25 cents per kilowatt-hour, and found these costs to align with commercial electricity rates averaged for the four largest utilities that serve the ports (Southern California Edison, Los Angeles Department of Water and Power, Pacific Gas and Electric, and San Diego Gas & Electric) provided in the California Energy Commission Mid Case Revised Demand Forecast (California Energy Commission [CEC], updated February 21, 2018).[116]

To estimate the electricity costs, CARB staff used the average vessel stay (hours) by vessel type (Appendix A, Table VI; Appendix B, "SP Labor & Energy"), the average

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[116] California Energy Commission, Mid Case Revised Demand Forecast – February 21, 2018, https://www.energy.ca.gov/2017_energypolicy/documents/2018-02-21_business_meeting/2018-02-21_middemandcase_forecst.php (Accessed September 5, 2018).

electrical load (kilowatts) by vessel type (Appendix A, Table V) the annual number of vessel visits (see Appendix A, Tables XIII-A through XIII-D; Appendix B, "Vessel Visits") and electricity cost (Appendix A, Table VIII; Appendix B, "Electricity & Fuel").

Shore Power Labor Costs

Another cost associated with the use of shore power is the labor charge to plug-in and later disconnect the vessel from the shore side electricity. Staff requested this information in a survey sent to ports in April 2018 and used an average of the values provided to develop an estimated labor cost of $2,355 for each shore power visit.

Shore Power Terminal Equipment Maintenance Costs

Shore power infrastructure at ports and terminals requires annual maintenance. Survey respondents indicated a wide range of costs from which staff calculated an average annual maintenance cost of $24,285 per each container and reefer berth retrofit and $50,000 per each cruise berth retrofit. Staff also received verbal information through conversations with terminal operators at POLB that led staff to conclude that the calculated average cost was a reasonable representation of annual maintenance costs. Across vessel types, maintenance costs would total less than 5 percent of annualized capital costs in a given year.

Shore Power Vessel Equipment Maintenance Costs

The June 2018 vessel operator survey also requested information on the annual maintenance cost of the equipment. Based on the range of cost values provided by vessel operators, staff calculated the average annual maintenance cost of $10,000 per vessel across all vessel types and applied this cost to the number of vessels (83) expected to install shore power as a result of the Proposed Regulation. Staff assumes the vessel equipment maintenance costs would be incurred by the vessel operators.

Shore Power Fuel Savings

Staff expects electricity costs incurred by terminal operators and passed along to vessel operators would be offset by the fuel savings from shutting down the vessel's auxiliary engines. To estimate these cost savings, staff estimated marine gas oil (MGO) fuel prices through 2032 by obtaining current MGO prices at POLA and POLB and projecting forward annually through 2032 using 2018 U.S. Energy Information Administration[117,118] projections for transportation diesel fuel, the closest surrogate for MGO. This methodology is further described in Appendix A, Table VIII.

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[117] U.S. Energy Information Administration, Annual Energy Outlook 2018 with projections to 2050 (February 2018), https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf.

[118] U.S. Energy Information Administration, Table: Petroleum and Other Liquids Prices, Annual Energy Outlook 2018, https://www.eia.gov/outlooks/aeo/data/browser/#/?id=12-AEO2018&cases=ref2018&sourcekey=0.

To estimate the fuel savings, CARB staff used the average vessel stay (hours) by vessel type, the average engine power load (kilowatts) by vessel type, the average fuel consumption rate for marine auxiliary engines, and the projected cost of MGO as described above. These input values are provided in Appendix A, Tables V and VIII, and Appendix B, “SP Labor & Energy” and “Electricity & Fuel”.

Low Carbon Fuel Standard Credits

The CARB Low Carbon Fuel Standard (LCFS) is a regulation designed to reduce carbon intensity of California’s transportation fuel pool and provide an increasing range of low-carbon and renewable alternatives, which reduce petroleum dependency and achieve air quality benefits. Starting 2019, electricity supplied as shore power to ocean-going vessels was included as an eligible low-carbon transportation fuel and eligible for generating LCFS credits.

For shore power, the owner of the location or facility where electricity is dispensed for fueling is the default eligible party to generate LCFS credits. However, it can contractually designate a third-party to be the credit generator on its behalf. Therefore, for shore power, the credit generator would be the port or the terminal, unless these parties agreed to designate another party as the credit generator. Staff expects that all parties eligible to generate LCFS credits would take advantage of the incentive provided by the LCFS.

Staff projected annual LCFS credit values of 0.10 to 0.11 $/kW-hr for shore power electricity throughout the cost analysis period based an analysis from LCFS staff dated April 12, 2019 (see Appendix A, Table VIII and Appendix B, “Electricity & Fuel” and “SP Labor & Energy”). For the ports that directly generate credits for shore power or receive the proceeds from resulting credits claimed by a designee on their behalf, staff expects approximately $6.3 million in costs savings to the ports between 2021 and 2032.

b. Land-Based Capture and Control Costs

For the purpose of the SRIA, staff assumes that tanker vessels would use land-based capture and control systems to control emissions from vessel visits. As described in this chapter, this assumption is based on extensive feedback and conversations with oil industry stakeholders, who stated they do not anticipate using shore power for reasons including the difficulty of equipping a global fleet of tanker vessels with shore power equipment. These stakeholders have also stated they do not anticipate using barge-based capture and control systems due to safety considerations that include the hazards inherent in aligning a barge alongside a tanker, in many cases where ocean currents are strong and would create substantial forces on vessel mooring systems.

Staff discussed two general configurations for implementing land-based capture and control systems at tanker terminals. Both configurations would utilize a similar emission control system, where exhaust gas is captured and routed to an emission control system, which would either be located on or alongside the wharf or on the shore.

However, the configurations would differ in the method that exhaust is collected from the vessel.

One configuration would involve a “bonnet” type system similar to the barge-based systems currently in existence, where exhaust gas is captured in a duct from the vessel stack and routed to an emission control system. The primary advantage to this type of technology is that it would not be expected to require any vessel-side equipment.[119] A disadvantage would be that at many terminal locations, this technology would require the construction of two large cranes at each berth to move the exhaust capture device potentially hundreds of feet to the vessel stack.

The second configuration would route exhaust gases to the vessel’s cargo manifold, which is the location on the vessel where crude oil or products are loaded on and off the vessel using specialized hoses that connect to the manifold to transfer the cargo to the terminal’s shoreside equipment. The disadvantage of this type of system is that it would require modifications to each vessel to route the exhaust to the manifold. Industry stakeholders generally do not believe this could be achieved in the time frame required by the Proposed Regulation due to difficulties in modifying a global fleet, and the current lack of universally accepted design standards for the vessel modifications that would be required.

Based on the above information, staff concluded that land-side “bonnet”-type capture and control system would likely be used at all tanker terminals statewide, and based its cost analysis on that assumption. As detailed in the Berth Analysis, CARB staff estimated that 33 land-based capture and control systems would be needed to control emissions from approximately 1,600 tanker and ro-ro vessel visits annually.

i. Summary of Annualized Land-Based Capture and Control Costs

Tables C7 and C8 summarize annualized direct costs for land-based capture and control systems that staff assumes would be incurred by ports and terminals as a result of the Proposed Regulation.

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[119] Staff communications with Tri-Mer Corporation in April 2018.

Table C7: Annualized Land-Based Capture and Control Costs Incurred by Ports

Year	Capital Costs	Maintenance Costs	Labor Costs	Feasibility Costs	Engineering Costs	Permitting Costs	Total
2020	$0	$0	$0	$929,000	$10,478,000	$3,493,000	$14,900,000
2021	$0	$0	$0	$929,000	$10,478,000	$3,493,000	$14,900,000
2022	$0	$0	$0	$929,000	$10,478,000	$3,493,000	$14,900,000
2023	$0	$0	$0	$929,000	$10,478,000	$3,493,000	$14,900,000
2024	$37,061,000	$0	$0	$929,000	$10,478,000	$3,493,000	$51,960,000
2025	$37,363,000	$0	$0	$929,000	$10,478,000	$3,493,000	$52,263,000
2026	$37,779,000	$0	$0	$929,000	$10,478,000	$3,493,000	$52,679,000
2027	$38,186,000	$1,058,000	$6,494,000	$0	$0	$0	$45,738,000
2028	$38,596,000	$1,069,000	$6,563,000	$0	$0	$0	$46,228,000
2029	$39,012,000	$1,080,000	$6,633,000	$0	$0	$0	$46,726,000
2030	$39,436,000	$1,092,000	$6,704,000	$0	$0	$0	$47,231,000
2031	$39,901,000	$1,105,000	$6,782,000	$0	$0	$0	$47,787,000
2032	$40,360,000	$1,117,000	$6,859,000	$0	$0	$0	$48,336,000
Total	$347,694,000	$6,521,000	$40,035,000	$6,503,000	$73,346,000	$24,451,000	$498,548,000

Table C8: Annualized Land-Based Capture and Control Costs Incurred by Terminals, in Thousands of Dollars

Year	Capital Costs	Feasibility Costs	Engineering Costs	Permitting Costs	Maintenance	Performance Testing Costs	Labor Costs	Operating Costs	Total
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0
2021	$0	$0	$0	$0	$0	$0	$0	$0	$0
2022	$0	$1,214	$19,531	$6,510	$0	$0	$0	$0	$27,256
2023	$0	$1,214	$19,531	$6,510	$0	$0	$0	$0	$27,256
2024	$7,846	$1,214	$19,531	$6,510	$0	$0	$0	$0	$34,750
2025	$7,923	$1,214	$19,531	$6,510	$44	$30	$0	$935	$35,826
2026	$105,882	$1,214	$19,531	$6,510	$45	$31	$0	$963	$133,804
2027	$107,016	$1,214	$19,531	$6,510	$1,280	$201	$7,576	$5,595	$148,540
2028	$108,162	$1,214	$19,531	$6,510	$1,295	$203	$7,657	$5,666	$149,846
2029	$109,326	$0	$0	$0	$5,672	$431	$26,532	$22,434	$163,993
2030	$110,507	$0	$0	$0	$5,733	$436	$26,816	$22,687	$165,768
2031	$111,806	$0	$0	$0	$5,801	$442	$27,129	$22,963	$167,721
2032	$113,089	$0	$0	$0	$5,867	$447	$27,438	$23,238	$169,649
Total	$781,557	$8,498	$136,717	$45,570	$25,737	$2,221	$123,148	$104,481	$1,224,409

ii. **Description of Costs for Ro-Ro Terminals**

The installation and utilization of emission control systems at ro-ro terminals would result in costs to the ports and terminals where this equipment is installed, and to the vessel operators who call the terminals. At ro-ro terminals, staff assumes that land-based capture and control systems would be similar in design and scale to the land-based and barge-based systems currently in operation. Therefore, staff assumes that infrastructure projects beyond the construction of the emission control system itself would not be required at ro-ro terminals. The costs associated with land-based capture and control systems at ro-ro terminals are described below, and further detail is provided on each cost element in Appendix A, Table III-A, Appendix B, “C&C-Containers & ro-ro”.

Ro-Ro Terminal Emission Control System Costs

Capture and control technology developers provided cost estimates to staff for the anticipated cost of an emission control system similarly sized to the 14,000 standard cubic foot per minute (scfm) land-based and barge-based systems currently in use. Staff understands that emission control systems required for ro-ro terminals would be similar in design and capacity to current systems, therefore staff used the provided cost values from both the barge-based ($4,900,000) and land-based systems ($3,600,000) to approximate costs for the emission control systems. Based on the Berth Analysis, three land-based systems are needed and assumes that the emission control system capital costs would be incurred by the Port of Hueneme for one system and the terminal operators at POLB and the Port of San Diego would incur the costs for two systems.

Labor Costs

On April 16, 2019, staff hosted a meeting with tanker industry stakeholders and Tri-Mer Corporation (Tri-Mer), which is a developer of air pollution control systems working with Clean Air Engineering-Maritime (CAEM), to discuss the process and challenges associated with adapting existing emission control systems developed by Tri-Mer/CAEM for use at tanker terminals. During this meeting, Tri-Mer stated that no additional labor is required to operate existing systems at container terminals beyond existing crane mechanics, and staff have no information at this time to indicate that additional labor would be needed at ro-ro terminals due to the similar design anticipated for systems at ro-ro terminals, which would use a positioning boom (similar to a crane) built into the capture and control system. Therefore, staff assumes that no additional labor costs would result from land-based capture and control systems at ro-ro terminals.

Maintenance Costs

A technology developer provided an annual cost estimate of $17,500 for maintenance of the emission control system, which includes potential repair costs, that was utilized in the cost analysis. Staff assumes that the terminal operators would incur the maintenance costs.

Operating Costs

A technology developer provided an hourly estimated charge of $100 per hour to the user for operation of the emission control system, which includes fuel and other consumables required to operate the system that was utilized in the cost analysis. Staff assumes that the terminal operators would incur the direct costs to operate the system, then charge the vessel operator to use the system.

Performance Testing Costs

The Proposed Regulation would require annual review of emission control systems performance to ensure they are controlling emissions as designed. Based on information from the capture and control technology providers, staff assumed that staff at the terminal would undertake the task of processing and reporting Continuous Emissions Monitoring System (CEMS) data to CARB to meet this requirement, and the terminal operators would incur a monthly cost of $1,000 for the data processing.

iii. **Description of Costs for Tanker Terminals**

As detailed in Appendix A, staff incorporated stakeholder information and feedback into the project elements anticipated for the planning and construction of infrastructure to support the use of land-based capture and control systems at tanker terminals, and into the cost estimates for these project elements. In addition to considering stakeholder information, staff also conducted its own research on elements of similar projects, including VOC capture infrastructure projects and Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) projects, to provide further confirmation of the information staff received from industry stakeholders. MOTEMS projects include wharf foundation upgrades, piping and piping support structure, and building mooring dolphins and have similar components to land-based capture and control systems. The cost elements anticipated for land-based capture and control projects at tanker terminals are discussed in further detail below.

Feasibility, Engineering and Permitting Costs for Tanker Terminals

Ports and tanker terminals would need to conduct feasibility assessments, engineering analysis and design, and secure required permits to construct terminal infrastructure projects needed to support the land-based capture and control systems. See Appendix A, Table IV; Appendix B, “C&C-Tankers” for more detail.

During meetings between staff, tanker industry stakeholders, Tri-Mer and CAEM, Tri-Mer stated that a feasibility study would be needed at each terminal to determine how the technology would be incorporated into the terminal's operations. Based on this discussion, staff incorporated a feasibility study cost of $500,000 per berth to be incurred by the tanker terminal operators.

Staff received estimated engineering costs from two industry stakeholders: Chevron and Marathon Petroleum. Based on this information, staff estimated that engineering costs would equal 12 percent of the total project capital costs.

Staff received estimated permitting costs from three industry stakeholders: Chevron, Marathon Petroleum, and Valero. Based on this information, staff estimated that permitting costs would equal 4 percent of total project capital costs.

Staff understands that feasibility, engineering and permitting generally occur in sequence but would overlap. Staff assumed that all of these costs would be spread evenly over a period of seven years prior to the implementation date applicable to each terminal.

Tanker Terminal Emission Control System and Infrastructure Costs

Ports and tanker terminals would need to install additional infrastructure to support land-based capture and control systems. The exact design and configuration of each system would be customized to each terminal and berth covered under the Proposed Regulation, based on the engineering analysis described above. However, staff worked with industry stakeholders to develop an understanding of how these land-based systems might be constructed at their facilities, and the elements that would be required. Staff received a letter from the Western States Petroleum Association (WSPA) on May 30, 2019, that aggregated input from five tanker terminal operators and provided cost assumptions for tanker terminal infrastructure projects.[120] Staff then conducted follow-up calls with the WSPA member companies that contributed information to corroborate and understand the information that was provided, prior to using it in the cost analysis.

Based on the above discussions, staff conservatively assumed for the cost analysis that the following infrastructure elements would be required at each tanker terminal exceeding the vessel visit threshold.
Cost assumptions and supporting information for all of the following elements are described in detail in Appendix A, Table III-B; Appendix B, "C&C- Tankers". Staff assumes these direct costs would initially be incurred by POLA and POLB for the terminals located there, and by the marine terminal operators in Northern California. Capture and control systems are currently in-use for some container vessel operators to comply with the requirements of the Existing Regulation. A shore-based system has been demonstrated for bulk vessels and additional barge systems are in productions.

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[120] Western States Petroleum Association comment letter to CARB, WSPA Input to CARB At Berth Cost Analysis for SRIA, May 2019.

The systems currently in-use have been designed to address the specific needs of the vessel types, port and terminals. For tankers, the existing system designs will need to be adapted to meet their needs and requirements.

- *Emission control system*. This refers only to the emissions treatment unit itself. The system could be a combined unit large enough to service emissions from multiple vessels simultaneously, or a single unit at each berth. Staff assumed that the emission control system would be scaled up from existing capture and control systems to accommodate the higher exhaust flow from tanker vessels, and that costs would scale in proportion to exhaust flow. Staff assumed a cost of $6,518,000 per system.

- *Emission control system connections and foundation support structure*. Terminal operators told staff that they generally believe electrical connections would be needed to operate the emission control system, as well as foundational support structures for the emission control systems. Staff assumes a cost of $7,000,000 per berth provided by WSPA in its letter dated May 30, 2019.[121] Terminal operators stated that support structures would not necessarily be needed at onshore locations. However, as needed, the support structure would reinforce the wharf on which an emission control system is placed, or be a standalone support structure separate from the wharf. In cases where a support structure is needed, the system would require construction of additional pilings into the sea floor. To account for the uncertainty regarding how many terminals would incur these costs, staff chose to use the mid-range value of provided by WSPA in its letter dated May 30, 2019 of $5,000,000 per berth at POLA and POLB tanker terminals and $15,000,000 at all other tanker terminals.

- *Piping infrastructure from berth to emission control system*. Piping and associated support structure would be needed to pipe exhaust from the vessel stacks to the emission control system. The piping distance could be hundreds or thousands of feet, depending on where the emission control system would be located relative to the point of exhaust. Staff assumed a cost of $4,500,000 per berth per berth. WPSA members concurred with this value in the WSPA letter dated May 30, 2019.

- *Crane(s).* Specially constructed crane(s) would be needed to move the exhaust capture device to the vessel stack(s). These cranes would need to be very large with a long reach. Staff assumed that one crane per berth would be needed at POLA and POLB and two cranes per berth would be needed at Northern California terminals. The primary reason for this difference is that most vessels at POLA and POLB are required to berth in one direction, where vessels calling at Northern California terminals need flexibility to berth in either the port or starboard side to accommodate vessels arriving and departing with the tides in San Francisco Bay. Since vessels are typically several hundred feet in length, a

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[121] Western States Petroleum Association comment letter to CARB, WSPA Input to CARB At Berth Cost Analysis for SRIA, May 2019.

centrally located single crane would not be a feasible solution to reach stacks on vessels berthing in opposite directions, in addition to the need to avoid conflicting with other terminal equipment.[122] Staff used the $7,000,000 costs provided in the WSPA letter dated May 30, 2019.

- *Crane support structure(s).* Similar to the emission control system, support structures would be needed for the crane(s) at each berth, regardless of whether the crane(s) were built on the wharf or on an adjacent standalone support structure. These structures would also require pilings into the sea floor. Since all cranes would need to be constructed either on or adjacent to the wharf, staff assumed the cost of $10,000,000 per crane support would apply to every berth.

Labor Costs

Based on feedback received from terminal operators, staff assumes that additional labor would be required to operate the land-based capture and control systems at tanker terminals, both to connect and disconnect the units, and to ensure safe operation continuously throughout each vessel visit. Conversations with terminal operators indicated that labor needs would vary depending on the site characteristics, such as the number of emission control systems at each terminal and the distance between berths. Based on these conversations, staff assumed that one additional full-time-equivalent staff would be needed at each berth to operate the capture and control system during vessel visits, as described in Appendix A, Table III-B; Appendix B, "C&C- Tankers". Staff believes that terminal operators would initially incur labor costs of $1,000,000 annually per berth to operate capture and control systems as a direct cost and would then pass the costs onto vessel operators calling the terminals.

Maintenance Costs

Terminal operators stated it would be difficult to estimate maintenance costs prior to having a complete understanding of what specific infrastructure would be needed at their terminals. The feedback received was speculative and highly variable. As a result, staff did not receive any information that was supported well enough to use in the cost analysis. Therefore, staff assumed that maintenance costs would be similar to maintenance costs for shore power infrastructure and developed a cost input for maintenance costs as 0.3% percent of capital costs, as described in Appendix A, Table III-B, Appendix B, "C&C- Tankers". Staff assumes terminal operators would incur maintenance costs as a direct cost.

Operating Costs

Operating costs include costs to operate the emission control system itself, as well as operating costs for associated infrastructure. Operating costs for the emission control

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[122] Chevron Comment Letter to CARB, Chevron Comments on the Control Measure for Ocean-Going Vessels At Berth: Cost Analysis Inputs and Assumptions and Cost Analysis for Standardized Regulatory Impact Assessment revised on 5/10/19, May 2019.

system include fuel (or electricity) to operate the system, and other consumables. Operating costs for associated infrastructure includes the energy costs to transport exhaust from the vessel to the emission control system. Staff assumed that terminal operators would directly incur costs of $200 per hour at tanker terminals at POLA and POLB and $500 per hour at all other tanker terminals. It is assumed that terminal operators would pass the costs on to vessel operators calling at the terminals.

Performance Testing Costs

The Proposed Regulation would require annual review of emission control systems performance to ensure they are controlling emissions as designed. Based on information from the capture and control technology providers, staff assumed that terminal staff would undertake the task of processing and reporting CEMS data to CARB to meet this requirement, and the terminal operators would incur a monthly cost of $1,000 per system for this data processing.

c. Barge-Based Capture and Control Costs

Based on the Berth Analysis, staff assumes that barge-based capture and control units would be used on: 1) a limited basis for container vessels and reefers, (e.g. a small number of vessels that would not install shore power) and 2) ro-ro vessels that visit berths that can accommodate barge-based systems. The Berth Analysis estimated seven barge-based systems would be needed.

i. **Summary of Barge-Based Capture and Control Costs**

Table C9 summarizes annual costs that staff assumes would be incurred by vessel operators for the use of barge-based capture and control systems for container, reefer, and ro-ro vessels. These costs are calculated based on the number and average duration of vessel visits expected to use this technology, and the hourly fee staff expects the vessel operators would be charged to use the system. The number of visits and the cost are expected to increase based on growth. These costs are further described below.

Table C9: Annual Costs for Barge-Based Capture and Control

Year	Barge-Based Capture and Control Costs
2020	$0
2021	$2,211,000
2022	$2,290,000
2023	$2,375,000
2024	$2,464,000
2025	$15,940,000
2026	$16,478,000
2027	$16,948,000
2028	$17,343,000
2029	$17,751,000
2030	$18,173,000
2031	$18,608,000
2032	$19,122,000
Total	$149,704,000

ii. Description of Costs

Hourly Costs Incurred by Vessel Operator

Capture and control systems are currently operated as a service provided by a third-party vendor and charged to the vessel operator on a fee per-hour basis. There are currently two companies providing capture and control service to container vessels at the POLA and POLB. To use this option, vessel operators contact the vendors that provide the service. The vendors coordinate with tugboat operators to move the barge alongside the vessel to be controlled. Cranes on the barge lift ducting that connects the vessel stack to the air pollution control systems on the barge. The hourly rate is inclusive of all costs to operate the control system, which include the tugboat operator and labor to connect the ducting to the stack. The rate charged to vessels can vary depending on the length of the stay, with shorter visits being more costly on an hourly basis. According to one provider, the average rate is $900 per hour for the container vessels now using the service, and a similar rate would apply to ro-ro vessels.

For container and reefer vessels, staff assumes that barge-based capture and control systems would be used to control emissions from vessels that are not expected to install shore power equipment as a result of the Proposed Regulation. For ro-ro vessels, staff assumes that barge-based capture and control systems would be used to control emissions from vessels that visit berths that can accommodate a barge-based system.

Capture and control systems also could be used in the event that a shore power-equipped vessel cannot connect to shore power, (e.g., equipment failure on the vessel or at the berth, inability to dock the vessel in a position that aligns with the shore side equipment, or other issues). Staff assumed that exceptions, TIEs, VIEs, or remediation fee visits would be used as applicable and accounted for them in calculating the vessel visits that would use capture and control barges (see Appendix A, Tables XIII-A through XIII-D).

Based on the Berth Analysis, a total of seven additional barge-based capture and control systems would be needed in response to the Proposed Regulation. This includes one shared contracted system at POLA and POLB for container and reefer vessels and one system each at POLA, POLB, Port of San Diego, Port of San Francisco, and the Richmond and Carquinez area ro-ro terminals.

Staff estimates 55 container and reefer visits would need to use capture and control systems, all at POLA and POLB for an average stay of 38.8 hours per visit. Due to the option of using TIEs, VIEs, and remediation fee visits in many cases, staff does not assume that back-up capture and control systems would be needed for container and reefer vessels. Staff estimates that almost 600 ro-ro visits would need to use capture and control systems at the ro-ro terminals described above for an estimated stay of 19.8 hours per visit. The number of visits and the related cost are increased by growth factors, with the first use by container and reefer vessels in 2021 and 2025 for ro-ro vessels.

d. Remediation Fund

Remediation costs would be incurred by terminal operators and vessel operators who choose to use this option in situations where emissions control cannot be achieved during a vessel visit, the vessel visit does not qualify for an exception, or where a TIE or VIE is not used for the vessel visit. The remediation costs would be placed into a fund that would be used for local emissions reduction projects to achieve the emission reductions that did not occur during the vessel visit. Assumed remediation costs are summarized in Table C10.

i. Summary of Remediation Fee Costs

Table C10: Remediation Costs for the Proposed Regulation

Year	Remediation Costs to Vessel Operators	Remediation Costs to Terminal Operators	Total Costs
2020	$0	$0	$0
2021	$0	$2,514,000	$2,514,000
2022	$0	$2,607,000	$2,607,000
2023	$0	$2,705,000	$2,705,000
2024	$0	$2,808,000	$2,808,000
2025	$0	$3,153,000	$3,153,000
2026	$0	$3,238,000	$3,238,000
2027	$243,000	$4,028,000	$4,271,000
2028	$246,000	$4,132,000	$4,377,000
2029	$248,000	$5,256,000	$5,504,000
2030	$251,000	$5,383,000	$5,634,000
2031	$254,000	$5,565,000	$5,819,000
2032	$257,000	$5,754,000	$6,011,000
Total	$1,498,000	$47,144,000	$48,642,000

ii. Description of Costs

Staff calculated the remediation costs by applying an estimated hourly remediation cost specific to each vessel type to the calculated percentage of vessel visits that staff estimated would use the fee in a year. This number of vessel visits is based on a staff analysis of CARB Enforcement data from 2017 documenting the reasons that vessels failed to connect to shore power and documentation of terminal or port construction that prevented shore power connection. Staff excluded vessel visits from this total that would have resulted in non-compliance with the Existing Regulation. Staff assumed that the same percentage of visits would encounter circumstances resulting in use of the remediation option in all analysis years.

The percentage of vessel visits assumed to use remediation fund is less than one percent and the hourly cost for remediation fees by vessel type are provided in Table C11.

Table C11: Hourly Remediation Cost for Terminal and for Vessel per Each Vessel Type

Vessel Type	Vessel Hourly Cost	Terminal Hourly Cost
Container/Reefer	$2,395	$2,395
Cruise	$12,879	$12,879
Auto/Ro-Ro	$1,515	$1,515
Product Tankers	$1,783	$1,783
Crude Tankers	$9,873	$9,873

e. Administrative Costs

Ports, terminal operators, vessel operators, and government agencies would all incur administrative costs as a result of the Proposed Regulation.

i. **Summary of Administrative Costs**

Administrative costs and the parties expected to incur each type of cost are summarized in Table C12, which includes costs to CARB and local, State, and federal agencies. These are fiscal impacts, therefore they are described in further detail in Chapter D, but are included in Table C13 because they are included in the total cost of the Proposed Regulation.

Table C12: Administrative Costs for the Proposed Regulation

Year	Port Plans	Terminal Plans	Vessel Visit Reports	Vessel Visit Reports	Infra-structure Project Reviews and Permitting*	CARB Technology Reviews and Enforce-ment*	Total Admin-istrative Costs
Cost Incurred by:	Ports	Terminal Operators	Terminal Operators	Vessel Operators	Local, State and Federal Agencies	CARB	All
2020	$301,000	$170,000	$0	$0	$0	$277,000	$748,000
2021	$309,000	$175,000	$897,000	$897,000	$945,000	$990,000	$4,214,000
2022	$0	$0	$921,000	$921,000	$940,000	$899,000	$3,681,000
2023	$0	$32,000	$945,000	$945,000	$940,000	$899,000	$3,762,000
2024	$0	$33,000	$972,000	$972,000	$940,000	$899,000	$3,815,000
2025	$0	$17,000	$1,008,000	$1,008,000	$940,000	$899,000	$3,871,000
2026	$0	$17,000	$1,029,000	$1,029,000	$940,000	$899,000	$3,914,000
2027	$0	$23,000	$1,051,000	$1,051,000	$940,000	$1,079,000	$4,143,000
2028	$0	$23,000	$1,074,000	$1,074,000	$940,000	$1,078,000	$4,189,000
2029	$0	$0	$1,098,000	$1,098,000	$940,000	$1,078,000	$4,215,000
2030	$0	$0	$1,124,000	$1,124,000	$940,000	$1,078,000	$4,267,000
2031	$0	$0	$1,162,000	$1,162,000	$940,000	$1,078,000	$4,342,000
2032	$0	$0	$1,201,000	$1,201,000	$940,000	$1,078,000	$4,420,000
Total	$611,000	$490,000	$12,482,000	$12,482,000	$11,285,000	$12,231,000	$49,581,000

*Described in Chapter D

ii. **Description of Costs**

Development of Port and Terminal Plans

The Proposed Regulation would require regulated ports and terminals to develop and submit plans to CARB staff for review detailing how the port/terminal would achieve emission reductions from vessels visiting each port/terminal. All ports and terminals would be required to develop and submit a plan by July 1, 2021.

Both ports and terminals would be required to list the division of responsibilities between their specific terminal and port entity (if a division exists) as part of their plan submittal. Defining the specific responsibilities for each party will assist CARB staff with enforcement of the Proposed Regulation, as responsibilities for installing emissions control equipment and making infrastructure improvements vary at every port and terminal, and are frequently dependent on the contract that exists between the two entities.

Staff assumes the per-unit cost of port plans is $10,000 per regulated terminal and 16 plans are required. Staff assumes the cost of terminal plans is $2,500 per berth and 55 plans are required.

Ports and terminals serving ro-ro and tanker vessels would be required to update and resubmit their terminal plans by July 1 prior to the implementation deadline for each vessel type and location. For ports and terminals serving ro-ro vessels, this due date would be July 1, 2024. For POLA, POLB, and their terminals serving tanker vessels, the due date would be July 1, 2026. For all other terminals serving tanker vessels, the due date would be July 1, 2028.

Vessel Visit Reporting

The Proposed Regulation would also require vessel operators and terminal operators to report information on each vessel visit by the vessel operator to the respective terminal to CARB within seven days of the visit. The costs for reporting to CARB would be incurred by the vessel and terminal operators.

Vessel operators and terminals would submit visit information electronically through CARB's electronic freight regulations reporting system (FRRS), which is currently under development, and is expected to help minimize the administrative costs to vessel operators and terminals by streamlining the reporting of vessel visit information.

For vessel operators, the required data includes information identifying the vessel, the location visited, the emission control strategy used, the start and end times of the visit and operation of the emission control equipment, the quantity and sulfur content of fuel used in auxiliary engines and crude tanker auxiliary boilers, and information and documentation for exceptions.

Terminal reporting requirements include information identifying the vessel, the port, terminal and berth visited; arrival and departure dates and times; any construction at the terminal that affects the ability to connect a vessel to an emissions control technology; the emission control method used; and the start and end times of emission control equipment if the method was provided by the terminal.

For vessel and terminal reporting, staff assumed an administrative cost of $100 per visit for each party. Staff believes that this is a conservatively high estimate due to the electronic reporting platform and the limited amount of information required to be reported.

f. Total Net Costs

Total net costs of the Proposed Regulation are summarized by vessel type in Table C13. These include all capital costs, feasibility, engineering, permitting, and administrative costs incurred by all parties less fuel savings and LCFS credit value.

Table C13: Total Costs of the Proposed Regulation

Year	Container/ Reefer	Cruise	Ro-Ro	Tankers	Bulk/General Cargo	Total
2020	$8,255,000	$13,706,000	$138,000	$15,107,000	$0	$37,206,000
2021	$15,639,000	$15,504,000	$498,000	$16,403,000	$209,000	$48,253,000
2022	$15,926,000	$15,990,000	$396,000	$43,494,000	$209,000	$76,014,000
2023	$16,172,000	$16,652,000	$435,000	$43,496,000	$209,000	$76,964,000
2024	$16,745,000	$17,220,000	$1,499,000	$87,350,000	$209,000	$123,022,000
2025	$17,448,000	$17,836,000	$16,053,000	$87,719,000	$209,000	$139,264,000
2026	$18,232,000	$18,457,000	$16,519,000	$186,066,000	$209,000	$239,482,000
2027	$18,740,000	$19,107,000	$17,027,000	$194,806,000	$209,000	$249,888,000
2028	$19,197,000	$19,761,000	$17,410,000	$196,575,000	$209,000	$253,152,000
2029	$19,694,000	$20,439,000	$17,801,000	$212,182,000	$209,000	$270,325,000
2030	$20,233,000	$21,149,000	$18,202,000	$214,444,000	$209,000	$274,235,000
2031	$20,890,000	$21,863,000	$18,612,000	$216,935,000	$209,000	$278,509,000
2032	$21,833,000	$22,614,000	$19,047,000	$219,392,000	$209,000	$283,095,000
Total	$229,004,000	$240,298,000	$143,635,000	$1,733,969,000	$2,503,000	$2,349,410,000

g. Data Source

i. **Berth Analysis**

Staff undertook extensive analysis of the berths anticipated to be included in the Proposed Regulation based on the proposed terminal visit threshold (Berth Analysis) to characterize what additional shore power infrastructure improvements and potential emission control technologies (land- or barge-based alternative capture and control systems) would be necessary to support the Proposed Regulation. For the development of the Berth Analysis, CARB staff relied on numerous sources, including:

- Port and Google Earth maps;
- Google Earth maps;
- Vessel visit information from Wharfinger, San Francisco Marine Exchange, and California State Lands Commission data;
- Comment letters received from industry stakeholders in response to the regulatory concepts released during the regulatory process (including public workshops, workgroup meetings, etc.);
- Numerous port/terminal site visits and tours; and
- Extensive discussions with terminal operators, port staff, and harbor pilots servicing the Northern and Southern California Ports.

The Berth Analysis was a crucial document in framing the development of the implementation timeline. The large amount of existing infrastructure that already exists at the ports that is subject to the Existing Regulation largely guided staff's decision to bring the currently regulated vessels (container, reefer, and cruise) in to the proposed regulatory structure at the 2021 date. The Berth Analysis also contains CARB staff's best assumptions of likely compliance pathways for different vessel types at specific terminals. The assumptions made in the Berth Analysis and SRIA do not in any way limit a vessel or terminal's compliance pathways, but were used as best estimates to assess potential costs and time frames.

5. Direct Costs on Typical Businesses

Ports, terminals, and vessel operators would incur costs resulting from the Proposed Regulation. These costs are broken down above in Chapter C.1, and calculation methodologies are described in Chapter C as they relate to total costs of the Proposed Regulation. All the ports that would be affected by the Proposed Regulation are local government agencies; therefore, costs that would specifically be incurred by ports are also discussed in Chapter D1. Costs to terminals include infrastructure and maintenance costs that would not be incurred by the ports, and those costs would vary widely depending on the infrastructure needed and the specific contract terms between each port and each terminal. Costs to vessel operators include vessel-side shore power retrofit costs, labor, electricity costs (minus fuel savings and LCFS credit value), vessel-side equipment maintenance costs, hourly costs to obtain barge-based capture and control system services, and operating costs for land-based capture and control systems. Costs to each business would vary widely depending on the number of vessels needing retrofit, the length of vessel visits, and specific agreements with terminal operators on labor costs and use of capture and control systems.

Staff developed cost estimates specific to one small port (Port of Hueneme) and one large port (POLB) to use as examples of costs for a small and large port. Since both ports are government entities, these analyses are described in Chapter D.

6. Direct Costs on Small Businesses

Staff does not anticipate any direct costs to small businesses resulting from the Proposed Regulation. Due to the large capital and operating costs associated with vessel operations, terminal and vessel fleet operators are not small businesses.

7. Direct Costs on Individuals

The Proposed Regulation would not result in any direct costs to individuals. However, staff anticipates the Proposed Regulation would result in indirect costs to individuals to the extent that compliance costs are passed through to the ultimate consumers of cargo, and cruise vessel passengers.

To estimate these indirect costs to consumers, staff calculated cost ratios in metrics of increased cost per 20-foot equivalent unit (TEU) of cargo for container and reefer vessels, increased cost per cruise vessel passenger, increased cost per automobile imported into or exported from California, and increased cost per gallon of gasoline, diesel fuel or jet fuel produced in California from crude oil imports into California ports and marine terminals.

Staff performed this analysis for year 2030 because that would be the first full year after the final implementation deadline for the Proposed Regulation. Table C15 summarizes the annualized cost in 2030, the total units (TEUs, passengers, automobiles and gallons of gasoline, diesel fuel and jet fuel) in 2030, and the calculated cost increase per unit. The methodologies used to calculate each cost are detailed in Appendix D.

Table C15: Estimated Net Costs to Individuals from the Proposed Regulation

Vessel Type	Annualized Cost in 2030	Total Units in 2030	Cost per unit in 2030	Unit
Container/Reefer	$20,233,000	15,590,200	$1.30	TEU
Cruise	$21,149,000	4,031,800	$5.25	Passenger
Ro-Ro	$18,244,000	2,437,300	$7.49	Automobile
Tanker	$214,444,000	27,156,860,144	$0.008	Gallons

D. FISCAL IMPACTS

This chapter describes costs and benefits that would be incurred by local, State and federal agencies due to the Proposed Regulation. Agencies that may be affected include several regulated public ports, CARB, CSLC, local air districts, and federal agencies that deal with waterways. In addition, the Proposed Regulation results in health benefits to individuals in California. These benefits may translate to cost savings for State and local healthcare providers.

1. Local Government

a. Direct Costs to Ports

The eight regulated ports that would incur costs from the Proposed Regulation (Los Angeles, Long Beach, San Diego, Hueneme, San Francisco, Oakland, Stockton, and Richmond) are all semi-autonomous public agencies that are each run by a Board of Commissioners, which are generally appointed by local city and/or county governments, or elected locally.[123,124,125,126,127,128,129,130] While each port has unique operating characteristics, the ports are generally self-funded and raise their own revenue through terminal leases or berthing fees. These funds are then used for infrastructure development and operational costs.

Some ports would face fiscal impacts to finance, design and build, and maintain shore power infrastructure, and/or infrastructure associated with land-based capture and control projects. Staff understands that infrastructure costs for projects occurring at port-based terminals would initially be incurred by the ports, but could be passed on to port tenants through their lease agreements, to vessel operators through berthing fees, or would be absorbed by the ports.

The ports would also incur administrative costs to cover the preparation of Port Plans that would be required by the Proposed Regulation, as described in Chapter C.4.e. Staff assumes that vessel operators, and terminal operators, rather than the ports would incur other administrative, labor, maintenance, and operating costs.

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[123] Port of Los Angeles, About the Port of Los Angeles, https://www.portoflosangeles.org/about (last accessed June 2019).

[124] Port of Long Beach, FAQs, http://www.polb.com/about/faqs.asp (last accessed June 2019).

[125] Port of San Diego, About the Port of San Diego, https://www.portofsandiego.org/about-port-san-diego (last accessed June 2019).

[126] Port of Hueneme, Vessel Schedule, https://www.portofhueneme.org/about/vessel-schedule/ (last accessed June 2019).

[127] Port of San Francisco, ABOUT THE PORT COMMISSION, https://sfport.com/aBOUT (last accessed June 2019).

[128] Port of Stockton, COMMISSION, https://www.portofstockton.com/meet-the-commissioners (last accessed June 2019).

[129] Port of Stockton, COMMISSION, https://www.portofstockton.com/meet-the-commissioners (last accessed June 2019).

[130] Port of Oakland, Board of Commissioners, https://www.portofoakland.com/port/board-of-commissioners/ (last accessed June 2019).

In cases where the ports are eligible to generate LCFS credits for shore power as discussed in Chapter C.4, the ports would directly benefit from LCFS credits. For example, Port of Oakland is a LCFS credit generator for supplying electricity as a low-carbon fuel for shore power. Because the ports typically own and dispense shore power for container and reefer vessels under the Existing Regulation, staff assumed that LCFS credit revenue for container and reefer vessel visits under the Proposed Regulation would be a direct cost savings to ports (see Appendix A, Table XIII-A).

For the purpose of the SRIA, staff assumes that for cruise vessels, where vessel operators are charged metered electricity costs by the terminals under the Existing Regulation, the terminal operator would typically be the fueling supply entity, and would receive the LCFS credits. Therefore, staff did not include LCFS credits for cruise vessels as a cost savings to ports.

The direct costs to ports are summarized in Table D1.

Table D1: Estimated Annual Direct Costs and Savings to Ports Under the Proposed Regulation*, Thousands of Dollars

Year	Capital Costs for Shore Power Infra-structure	Maintenance Costs for Shore Power Infra-structure	Shore Power Labor Costs	Shore Power Energy Costs	LCFS Credits	Capital Costs for Land-Based Capture and Control Infra-structure	Land-Based Capture and Control Labor Costs	Land-Based Capture and Control Mainten-ance Costs	Land-Based Capture and Control Feasibility, Engineering and Permitting Costs	Admin-istrative Costs	Total Annual Direct Costs to Ports
2020	$8,659	$0	$0	$0	$0	$0	$0	$0	$14,900	$301	$23,860
2021	$8,977	$60	$218	$0	$0	$0	$0	$0	$14,900	$309	$24,464
2022	$9,307	$62	$226	$0	$0	$0	$0	$0	$14,900	$0	$24,495
2023	$9,651	$65	$235	$272	-$163	$0	$0	$0	$14,900	$0	$24,959
2024	$10,008	$67	$244	$284	-$168	$37,061	$0	$0	$14,900	$0	$62,395
2025	$10,398	$69	$256	$304	-$169	$37,363	$0	$0	$14,900	$0	$63,121
2026	$10,766	$72	$263	$310	-$175	$37,779	$0	$0	$14,900	$0	$63,916
2027	$11,150	$75	$271	$319	-$182	$38,186	$6,494	$1,058	$0	$0	$57,371
2028	$11,550	$77	$279	$330	-$189	$38,596	$6,563	$1,069	$0	$0	$58,276
2029	$11,965	$80	$288	$344	-$197	$39,013	$6,633	$1,080	$0	$0	$59,206
2030	$12,397	$83	$297	$358	-$205	$39,436	$6,704	$1,092	$0	$0	$60,162
2031	$12,867	$86	$310	$377	-$219	$39,901	$6,782	$1,105	$0	$0	$61,210
2032	$13,356	$89	$324	$397	-$233	$40,360	$6,859	$1,117	$0	$0	$62,269
Total	$141,050	$887	$3,211	$3,296	-$1,899	$347,694	$40,035	$6,520	$104,297	$611	$645,703

*Ports include Los Angeles, Long Beach, Oakland, San Francisco, San Diego, Hueneme, Richmond, and Stockton. Ports do not include the independent marine terminals located in the Stockton and Richmond areas.

Staff is analyzing the direct net costs to a large and small port to look at the potential fiscal impact of these projects on the ports.

i. Direct Costs to a Large Port – Port of Long Beach

POLB receives all vessel types covered under the Proposed Regulation.[131] Significant shore power infrastructure already has been installed at POLB to meet the requirements of the Existing Regulation for container, reefer and cruise vessels. Tanker and ro-ro vessels would be required to control emissions for the first time under the Proposed Regulation. As described in the Berth Analysis, tanker vessels are assumed to use land-based capture and control system, and ro-ro vessels would use a combination of land-based and barge-based capture and control system.

Shore Power Infrastructure

Staff conversations with many of the terminal operators at POLB indicated they do not anticipate needing additional infrastructure to comply with the Proposed Regulation, beyond what would already be needed to comply with the Existing Regulation, Proposition 1B: Goods Movement Emission Reduction Program (Proposition 1B) requirements, and other existing environmental mitigation agreements.

POLB received public monies through the Proposition 1B program to co-fund roughly half the cost of installing shore power at 13 of its 20 container, reefer, and cruise berths.[132] The legal contract between the Port and the administering air district requires each funded berth to utilize shore power for vessel visits at a rate 10 percent above the visit requirements in the Existing Regulation (i.e., when the Existing Regulation requires 80 percent of vessel visits to be controlled in 2020, shore power at a Proposition 1B-funded berth must be used for at least 90 percent of visits to that berth through December 31, 2023). [133]

The Port provided an engineering estimate of potential infrastructure additions and costs to make 100 percent of berths shore power compatible, regardless of which way a vessel is berthed (port or starboard). POLB may need to expand its shore power infrastructure to meet its existing 2020 obligations, which may account for the engineering analysis.

Staff has assumed no additional shore power capital projects would be required at POLB to meet the incremental increase of visits controlled with shore power under the Proposed Regulation. This is because the shore power infrastructure needed to meet the Existing

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[131] Port of Long Beach, Facts At a Glance, http://polb.com/about/facts.asp.

[132] Listed as 12 berths in the California Air Resources Board, Annual Report on Implementing the Proposition 1B: Goods Movement Emission Reduction Program, "TABLE 3A (continued) LOS ANGELES/INLAND EMPIRE TRADE CORRIDOR – South Coast AQMD," page 9, as two berths are reported as one berth for funding. https://ww3.arb.ca.gov/research/apr/reports/goods-movement-emission-reduction2019.pdf?_ga=2.158687482.1342487641.1562875568-507178590.1562019541.

[133] California Air Resources Board, PROPOSITION 1B: GOODS MOVEMENT EMISSION REDUCTION PROGRAM, FINAL 2015 GUIDELINES FOR IMPLEMENTATION, Appendix J. Shore Power Equipment Project Specifications, page J-15, https://ww3.arb.ca.gov/bonds/gmbond/docs/prop_1b_goods_movement_2015_program_guidelines_for_implementation.pdf.

Regulation's 80 percent requirement in 2020 and Proposition 1B's additional 10 percent requirement would provide sufficient shore power capacity to meet the requirements of the Proposed Regulation.

Land-Based Capture and Control Infrastructure

For the land-based capture and control systems, significant infrastructure would be required at the terminals that receive tanker vessels, while no additional infrastructure would be needed at terminals that receive ro-ro vessels that are expected to use a barge-based capture and control system.

Other Costs

All other costs, such as hourly capture and control barge utilization fees, labor, maintenance, operating costs, administrative costs (excluding the Port Plans) and remediation fee costs would not be incurred by the Port. Staff anticipates terminal operators, vessel operators, or State, local, or federal agencies, would incur these costs. Based on the above staff assumes that POLB would incur the following costs:

- Land-based capture and control capital equipment costs (including construction and installation) for terminals receiving tanker vessels
- Land-based capture and control feasibility study costs for tanker terminals
- Land-based capture and control infrastructure project engineering costs for tanker terminals
- Land-based capture and control infrastructure project permitting costs for tanker terminals
- Administrative costs to prepare Port Plans

Costs applicable to POLB are summarized in Table D2.

Table D2: Regulation Costs for Port of Long Beach

Year	Capital Costs for Land-Based Capture and Control Infrastructure (Tankers and Ro-Ro)	Capture and Control Equipment Maintenance Costs (Tankers)	Feasibility, Engineering, Permitting, Administrative Costs	Total Direct Costs
2020	$0	$0	$8,093,000	$8,093,000
2021	$0	$0	$8,023,000	$8,023,000
2022	$0	$0	$8,023,000	$8,023,000
2023	$0	$0	$8,053,000	$8,053,000
2024	$19,766,000	$0	$8,023,000	$27,789,000
2025	$19,924,000	$0	$8,053,000	$27,976,000
2026	$20,142,000	$0	$8,023,000	$28,165,000
2027	$20,355,000	$1,058,000	$0	$21,413,000
2028	$20,571,000	$1,069,000	$0	$21,640,000
2029	$20,791,000	$1,080,000	$0	$21,871,000
2030	$21,014,000	$1,092,000	$0	$22,105,000
2031	$21,259,000	$1,105,000	$0	$22,363,000
2032	$21,501,000	$1,117,000	$0	$22,618,000
Total	$185,322,000	$6,520,000	$56,290,000	$248,133,000

Based on data from the POLB 2018 Comprehensive Annual Financial Report (CAFR)[134] the average annual increase in net position[135] for the Port of Long Beach, in the two years ending September 30, 2018 and September 30, 2019, was approximately $151 million. Operating revenues from port customers and other sources averaged approximately $384 million in the same two years. From 2020 to 2032, the average annualized direct costs to the Port of Long Beach is approximately $19 million, about five percent of the average operating revenue or 13 percent of the port's average change in net position as reported in the Port of Long Beach 2018 CAFR. [136] If, for example, the port decided to absorb half of the direct costs of the Proposed Regulation and pass the other half of the direct costs onto its customers, and the financial circumstances were similar to those reported in the 2018 CAFR, then the Proposed

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[134] The Harbor Department of the City of Long Beach, 2018 Comprehensive Annual Financial Report, http://www.polb.com/civica/filebank/blobdload.asp?BlobID=15008. (Accessed July 15, 2019).

[135] The difference between all revenues and expenses.

[136] The Harbor Department of the City of Long Beach, 2018 Comprehensive Annual Financial Report. http://www.polb.com/civica/filebank/blobdload.asp?BlobID=15008, (Accessed July 15, 2019).

Regulation could result in approximately a 2.5 percent increase in costs to port customers and a 6.5 percent decrease in net position growth of the port.

When comparing these results from the 2018 CAFR results to the average annualized costs of the Proposed Regulation for POLB from 2020 to 2032, it is important to note that the cost analysis assumes a certain growth in costs to account for increases in freight activity. These increases in freight activity could also be reflected in increases in port operating revenues, making the potential impact to ports and customers presented here a conservative upper bound.

ii. **Direct Costs to a Small Port – Port of Hueneme**

The Port of Hueneme receives container, reefer and ro-ro vessels. Shore power infrastructure has already been installed at the three container/reefer berths included in the Proposed Regulation at the Port of Hueneme to meet the requirements of the Existing Regulation. All three were co-funded by the Proposition 1B program and come with the 10 percent increase in required shore power usage described above for POLB.[137] The requirement for 90 percent of visits to be controlled begins January 1, 2020 and continues through December 31, 2023, which is the end of the Proposition 1B contract.

Under the Proposed Regulation, ro-ro vessels would be required to control emissions for the first time. As described in the Berth Analysis, staff assumes that ro-ro vessels at the Port of Hueneme would use land-based capture and control system based on discussions with port staff who advised there is no room for a barge-based system due to space constraints.[138]

Shore Power Infrastructure

Based on the Berth Analysis and staff discussions with the Port of Hueneme, staff understood that they would not need additional shore power infrastructure for the incremental increase in container or reefer vessels that would use shore power at the Port. Therefore, staff assumes no additional shore power capital projects would be needed at the Port of Hueneme to meet the requirements of the Proposed Regulation.

Land-Based Capture and Control Infrastructure

Because the Port of Hueneme operates the terminals, they would incur costs for the land-based capture and control systems installed at the ro-ro terminals. Based on the Berth Analysis and staff discussions with the Port of Hueneme, staff understood that they would not need supporting wharf improvements for the system.

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[137] California Air Resources Board, Annual Report on Implementing the Proposition 1B: Goods Movement Emission Reduction Program, “TABLE 3A (continued) LOS ANGELES/INLAND EMPIRE TRADE CORRIDOR – South Coast AQMD,” page 9, https://ww3.arb.ca.gov/research/apr/reports/goods-movement-emission-reduction2019.pdf?_ga=2.158687482.1342487641.1562875568-507178590.1562019541.

[138] California Air Resources Board, CARB Staff Analysis of Potential Emission Reduction Strategies by Port/Terminal/Berth For Auto/Ro-Ro Vessels (May 2019), https://ww3.arb.ca.gov/ports/shorepower/meetings/051419/autororoanalysis.pdf.

Other Costs

All other costs, such as labor, maintenance, operating costs, administrative costs (excluding the Port Plans) and remediation fee costs would not be incurred by the Port. Staff anticipates these costs would be incurred by either the terminal operators, the vessel operators, or State, local and federal agencies.

Based on the above, staff assumes the Port of Hueneme would incur the following costs:

- Land-based capture and control capital equipment costs for berths receiving ro-ro vessels
- Administrative costs to prepare Port Plans

Costs applicable to the Port of Hueneme are summarized in Table D3.

Table D3: Regulation Costs for Port of Hueneme

Year	Capital Costs for Land-Based Capture and Control Infrastructure (Ro-Ro)	Administrative Costs	Total Direct Costs
2020	$0	$10,000	$10,000
2021	$0	$0	$0
2022	$0	$0	$0
2023	$0	$30,000	$30,000
2024	$352,000	$0	$352,000
2025	$362,000	$0	$362,000
2026	$373,000	$0	$373,000
2027	$384,000	$0	$384,000
2028	$392,000	$0	$392,000
2029	$401,000	$0	$401,000
2030	$411,000	$0	$411,000
2031	$420,000	$0	$420,000
2032	$430,000	$0	$430,000
Total	$3,525,000	$40,000	$3,565,000

Based on data from the Port of Hueneme CAFR[139] the annual average increase in net position for the Port of Hueneme, in the two years ending June 30, 2018 and June 30, 2019, was approximately $2 million. Operating revenues averaged $16 million in the same 2 years. From 2020 to 2032, the average annualized direct cost to the Port of Hueneme is approximately $0.3 million, about 2 percent of the average operating revenue or 22 percent of the port's average change in net position as reported in the Port of Hueneme 2018 CAFR. If, for example, the port decided to absorb half of the costs of the regulation and pass the other half of the costs onto its customers, and the financial circumstances were similar to those reported in the 2018 CAFR, then the regulation could result in approximately a 1.0 percent increase in costs to port customers and a 7 percent decrease in net position growth.

Similar to the discussion regarding POLB, when comparing the 2018 CAFR results to the average annualized costs from 2020 to 2032, it is important to note that the cost analysis assumes a certain growth in costs to account for increases in freight volume. These increases in freight volume could also be reflected in increases in port operating revenues, making the potential impact to ports and customers presented here a conservative upper bound.

b. Cost-Savings from Avoided Health Impacts

With the reduction in toxic DPM, plus PM2.5 and NOx emissions resulting in improved air quality, it is expected that local governments would benefit from fewer employee sick days and a reduction in public hospital and ER visits. The Proposed Regulation would lead to some cost savings, but the share of cost savings attributable to the local government is not easily quantified. Based on the spatial distribution of emissions reductions and associated health benefits (Table B7), most avoided hospitalizations and ER visit cost savings would occur in the South Coast and San Francisco Bay air basins. Local governments would also benefit from a greater ability to attain regional air quality goals.

The reduction in DPM, PM2.5 and NOx emissions would also result in less occupational air pollution exposure to workers at ports and terminals. Staff did not specifically quantify the reduction in occupational exposure; however, to the extent that port and some terminal workers are local government employees, the Proposed Regulation would further reduce health care costs associated with air pollution from the regulated vessel visits.

c. Local Permitting Requirements

Staff assumes that infrastructure improvements for shore power berth retrofits and for infrastructure projects to support land-based capture and control systems at tanker and ro-ro terminals would require local agency (air districts) staff time to review and issue permits for such projects. The extent of staff time required would depend on the individual project and the lead permitting agency.

Land-based capture and control systems would also require local air district permits, or inclusion in the facility's federal Title V operating permit for systems located at major sources of air pollution. District permits would require review by local air district staff. For purposes of

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[139] The Port of Hueneme, Comprehensive Annual Financial Report, https://www.portofhueneme.org/wp-content/uploads/2019/01/FY-2018-CAFR-Oxnard-Harbor-District.pdf (Accessed July 15, 2019).

the cost analysis, staff assumes that the equivalent of one additional personnel year (PY) would be needed during the implementation timeframe of the Proposed Regulation to account for local permitting activities.

Local agency personnel costs are summarized in Table D4 and the cost is assumed to be equivalent to a CARB Air Resources Engineer as shown in Table D6.

Table D4: Annual Personnel Costs for Local Agencies

Year	Costs
2020	$0
2021	$189,000
2022	$188,000
2023	$188,000
2024	$188,000
2025	$188,000
2026	$188,000
2027	$188,000
2028	$188,000
2029	$188,000
2030	$188,000
2031	$188,000
2032	$188,000
Total	$2,257,000

a. Changes in Local Government Taxes

The Proposed Regulation would affect local government finances through a change in revenues due to the increase in the use of electricity as a result of increased shore power usage. Local utility taxes differ depending on city and county. Staff calculated an average of local utility use taxes in cities where ports are located using the most recent data of utility use taxes.[140] This calculation resulted in a utility use tax of approximately 8 percent. Changes in utility use taxes were estimated by multiplying this percentage by increased spending on electricity under the Proposed Regulation.

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[140] California Secretary of State, 2018. California Cities Utility Users Tax Revenue and Rate. https://sco.ca.gov/Files-ARD-Local/LocRep/2016-17%20LAFCO_Cities%20by%20County.pdf. Published Dec. 10th 2018.

The Proposed Regulation could also affect local government finances if decreases in marine gas oil that is used while vessels are at berth impact revenues from California sales and use tax. Fuel sold to vessels is exempt from sales tax after the vessel reaches its first out-of-state destination.[141] If the amount of fuel on board the vessel on arrival at the California port is sufficient to enable the vessel to reach its first out-of-state destination, then the quantity of fuel purchased in California is exempt from tax.[142] To illustrate the maximum potential impact on state finances, this analysis presents the potential change in local tax revenue if all of the vessel fuel savings impacted California taxes. However, depending on vessel fueling practices, there could possibly be no impact on state tax revenue due to the Proposed Regulation. The portion of California sales tax going to local government differs by city. Staff calculated an average local tax rate of approximately 5 percent using the most recent data on local tax sales and use tax rates.[143] Decreases to state tax revenue as a result of the Proposed Regulation is obtained by multiplying this percentage by the vessel fuel savings.

The year by year changes to local government finances due to the utility use tax is summarized in Table D5.

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[141] California Department of Tax and Fee Administration, Sales and Use Taxes: Exemptions and Exclusions, California Revenue and Taxation Code Part 1, Division 2, https://www.cdtfa.ca.gov/formspubs/pub61.pdf (Accessed July 15, 2019).

[142] State Board of Equalization Staff Legislative Bill Analysis, Assembly Bill 846 (Blakeslee and Karnette)

[143] California Department of Tax and Fee Administration. Tax Rates by County and City. https://cdtfa.ca.gov/formspubs/cdtfa95.pdf. Accessed July 15, 2019. Average based on vessel visits and fuel savings.

Table D5 Annual Change in Local Tax Revenue

Year	Local Utility Use Tax Revenue	Local Sales Tax Revenue	Net Tax Change
2020	$0	-$0	$0
2021	$27,122	-$26,636	$486
2022	$27,872	-$28,755	-$883
2023	$79,851	-$67,460	$12,394
2024	$83,313	-$73,528	$9,785
2025	$88,227	-$79,490	$8,737
2026	$90,714	-$84,188	$6,527
2027	$93,797	-$89,947	$3,850
2028	$97,355	-$96,247	$1,108
2029	$101,728	-$103,125	-$1,398
2030	$106,307	-$109,750	-$3,442
2031	$111,322	-$118,265	-$6,943
2032	$116,574	-$126,347	-$9,773
Total	$1,024,182	-$1,003,738	$20,444

2. State Government

a. CARB

The Proposed Regulation is anticipated to require the following additional permanent, full-time CARB staff to successfully implement and enforce:

- Four new PYs to perform all the implementation functions once the Proposed Regulation is adopted

- Three new PYs for conducting enforcement activities for an expanded number of ports, terminals, vessel types, vessel fleets, and vessel visits once the Proposed Regulation is adopted

For the implementation resources, tasks would include: reviewing port and terminal compliance plans; identifying critical changes and working with ports and terminals to resubmit acceptable plans; preparing guidance documents to inform and assist regulated entities with compliance; answering letters, email, and phone calls from ports and industry; responding to environmental justice and community advocates on implementation progress and emission control performance at specific ports; coordinating with staff reviewing applications for technology approvals required for regulatory compliance and for incentive eligibility; performing the interim progress evaluation and presenting it to the Board in 2023; and monitoring the status of both land infrastructure development and construction of additional barge-based control systems.

The implementation resources would need to include the following full-time permanent CARB positions:

- One Air Resources Engineer, beginning in FY 20-21, for the technical duties on review of plans and technologies, as well as infrastructure development.

- Two Air Pollution Specialists, beginning in FY 21-22, to draft guidance documents, evaluate required At-Berth reports submitted in the Freight Regulations Reporting System and flag/resolve any issues, and work with environmental justice communities near ports.

- One Air Resources Technician II, beginning in FY 20-21, to staff the hotline for industry questions, and respond to industry/port requests for compliance assistance.

CARB staff notes that contract funds and the information technology resources for the new Freight Regulations Reporting System referenced above in this chapter to accommodate the reporting that would be required under the Proposed Regulation (and multiple other regulations) were provided in the FY 18-19 and FY 19-20 State Budgets. The FY 19-20 State Budget included new staff to perform Freight Technology Reviews and Approvals for a wide range of port and rail yard equipment, including emission control systems for ships at berth.[144] Without these actions, the CARB staff resource needs for the Proposed Regulation would be greater.

For the enforcement resources, CARB's Enforcement Division estimated that the following full time permanent CARB positions would be needed:

- One Air Resources Technician II and one Air Pollution Specialist would be needed beginning in 2021, the first year of implementation of the Proposed Regulation.

- One Air Pollution Specialist would be needed in 2027, the first year of implementation at the tanker terminals.

The need for increased enforcement would result from an increase in the number of regulated parties under the Proposed Regulation, the additional responsibilities and reporting requirements for ports, terminal and vessel operators, and the additional vessel types and vessel visits that would be required to reduce emissions under the Proposed Regulation.

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[144] State of California 2019-20 State Budget – EP 1, 3900 Air Resources Board, http://www.ebudget.ca.gov/2019-20/pdf/Enacted/GovernorsBudget/3890/3900.pdf.

The recent freight budget items did not include any resources specifically for implementation or enforcement of the Proposed Regulation (the additional functions described above), because the Regulation has not yet been adopted. CARB will seek these resources to augment the Reporting System and Technology Approval staff once the Board acts on the proposal.

PY cost assumptions and number of positions are provided in Table D6 and Annual PY costs for CARB staff are summarized in Table D7.

Table D6: CARB PY Positions and Costs

Position	Number of Positions	Initial Cost	Ongoing Cost
Air Resources Engineer	1	$189,000	$188,000
Air Pollution Specialist	4	$180,000	$179,000
Air Resources Technician II	2	$88,000	$87,000

Table D7: Annual Personnel Costs Incurred by CARB

Year	Costs
2020	$277,000
2021	$990,000
2022	$899,000
2023	$899,000
2024	$899,000
2025	$899,000
2026	$899,000
2027	$1,079,000
2028	$1,078,000
2029	$1,078,000
2030	$1,078,000
2031	$1,078,000
2032	$1,078,000
Total	$12,231,000

b. Other State Agencies

Staff assumes that infrastructure improvements would be needed at locations on State-owned lands (marine and port terminals) and that are under the jurisdiction of CSLC, primarily for infrastructure projects to support land-based capture and control systems at tanker terminals. Staff assumes that the CLSC would incur administrative costs to review and approve such projects.

Staff communicated with CSLC on the subject of their review of projects to support the Proposed Regulation, including a conference call held on March 27, 2019. Staff also discussed the CSLC review process with tanker terminal operators who have experience with the review process for prior infrastructure projects, including MOTEMS upgrades. CSLC emphasized that the staff hours they would incur to review tanker terminal infrastructure projects, as well as the review timeline, is highly variable and depends on a number of factors such as the number of terminal infrastructure projects, the timing of application submittals, staggering of projects based on priority, how much of the terminal infrastructure work would occur in the ocean, other environmental considerations, and the local permitting agencies involved. CSLC staff stated that staff could work on one or two projects simultaneously, and speculated that projects would need to be reviewed by a process/safety engineer, of which they currently have only one on staff. CSLC staff stated that they would need two PY's to handle the additional work.

CSLC is not a permitting agency, however permitting agencies typically will not issue permits for infrastructure projects until CSLC has reviewed and approved the project. State agencies directly involved in permitting may include the San Francisco Bay Conservation and Development Commission (BCDC),[145] applicable to projects in the San Francisco Bay, the applicable Regional Water Quality Control Board, and the California Department of Fish and Wildlife (CDFW).[146]

Based on the number of projects to be reviewed, staff estimates that in addition to the two PYs for CSLC, one additional PY would be needed to account for project review and permitting activities. The PY costs would be equivalent to an Air Resources Engineer at CARB as provided in Table D6 and annual costs are summarized in Table D7.

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[145] San Francisco Bay Conservation and Development Commission, Permits, https://bcdc.ca.gov/permits/

[146] California Department of Fish and Wildlife, Environmental Review and Permitting, https://www.wildlife.ca.gov/Conservation/Environmental-Review

Table D8: Annual Personnel Costs Incurred by Other State Agencies

Year	Costs
2020	$0
2021	$567,000
2022	$564,000
2023	$564,000
2024	$564,000
2025	$564,000
2026	$564,000
2027	$564,000
2028	$564,000
2029	$564,000
2030	$564,000
2031	$564,000
2032	$564,000
Total	$6,771,000

a. *State Government Tax Implications*

The Proposed Regulation will affect State finances through changes in fees collected through the electrical energy resources surcharge, a tax based on the kilowatt-hours consumed in California.[147] The electrical energy resources surcharge is set at $0.0003 per kilowatt-hour. The impact of the Proposed Regulation on revenue from the energy resources surcharge was estimated by multiplying this per kilowatt-hour rate by the additional kilowatt-hours of electricity used under the Proposed Regulation.

Similar to the local government impacts, the Proposed Regulation could also affect State finances if decreases in marine gas oil that is used while vessels are at berth impacts revenues from California sales and use tax. To illustrate the maximum potential impact on State finances, this analysis presents the potential change in State tax revenue if all of the vessel fuel savings impacted California taxes. However, depending on vessel fueling practices, there could possibly be no impact on State tax revenue due to the Proposed Regulation. The State portion of the California sales tax is 3.94%.[148] Decreases to State tax

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[147] California Department of Tax and Fee Administration, 2019 Electrical Energy Surcharge Rate, https://www.cdtfa.ca.gov/taxes-and-fees/l590.pdf (Accessed July 15, 2019).

[148] California Department of Tax and Fee Administration, Detailed Description of the Sales & Use Tax Rate. https://cdtfa.ca.gov/taxes-and-fees/sut-rates-description.htm (Accessed July 15, 2019).

revenue as a result of the Proposed Regulation is obtained by multiplying this percentage by the vessel fuel savings.

The year-by-year changes in State government tax revenue as a result of increased electricity use, and the potential change in State government tax revenue as a result of vessel fuel savings is presented in Table D9.

Table D9: Annual Changes in State Government Tax Revenue

Year	Electrical Energy Resources Surcharge	Sales and Use Tax	Net Tax Change
2020	$0	-$0	$0
2021	$632	-$21,481	-$20,849
2022	$656	-$23,189	-$22,534
2023	$1,872	-$51,923	-$50,051
2024	$1,942	-$56,593	-$54,650
2025	$2,033	-$61,182	-$59,149
2026	$2,095	-$64,797	-$62,702
2027	$2,161	-$69,230	-$67,069
2028	$2,231	-$74,079	-$71,848
2029	$2,304	-$79,373	-$77,069
2030	$2,381	-$84,472	-$82,090
2031	$2,482	-$91,026	-$88,544
2032	$2,587	-$97,247	-$94,660
Total	**$23,376**	**-$774,592**	**-$751,216**

3. Federal Government

Staff assumes that certain infrastructure improvements occurring at locations on State-owned lands under the jurisdiction of the CSLC may also require the review of federal agencies in some cases, potentially including the United States Army Corps of Engineers (USACE), the United States Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS). Staff does not expect the federal agencies to review most improvements solely on land, but they may be involved in some oil terminal land-based capture and control system wharf improvements that extend into navigable waterways.

The extent to which these federal agencies would incur staff time to review projects resulting from the Proposed Regulation depends on various factors including the location, scope, and environmental concerns specific to individual projects. For the purposes of the cost analysis, staff assumes that the combined staff cost for federal agencies to review projects would be one additional PY, at a PY cost equivalent to an Air Resources Engineer at CARB as provided in Table D6 and these costs are summarized in Table D10.

Table D10. Annual Personnel Costs for Federal Agencies

Year	Costs
2020	$0
2021	$189,000
2022	$188,000
2023	$188,000
2024	$188,000
2025	$188,000
2026	$188,000
2027	$188,000
2028	$188,000
2029	$188,000
2030	$188,000
2031	$188,000
2032	$188,000
Total	$2,257,000

E. MACROECONOMIC IMPACTS

1. Methods for Determining Economic Impacts

This section describes the estimated total impact of the Proposed Regulation on the California economy. The Proposed Regulation will result in increases to costs to ports, terminals, and vessel operators and increase demand in sectors that supply equipment and infrastructure for shore power and capture and control technologies. The changes in costs and demand will affect employment, output, and investment in sectors that supply goods and services to these industries. While the direct compliance costs of the regulation are large, they are also borne by large industries. By the time the impacts of the regulation work their way through the economy, the macroeconomic modeling shows a small impact on economic indicators such as gross State product, employment, output, and the personal income of individuals in California, as described in further detail in this section. The analysis focuses on the incremental change in these economic indicators from 2020 to 2032.

The costs and benefits discussed in Sections B and C are input into Regional Economic Models, Inc. (REMI), Policy Insight Plus Version 2.2.8 to estimate the macroeconomic impacts of the Proposed Regulation under the Baseline. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric, and economic geography methodologies. REMI provides year-by-year estimates of the total economic impacts of the Proposed Regulation and alternatives, meeting the requirements of the Administrative Procedure Act and its implementing regulations.[149] CARB uses the REMI single-region, 160-sector model with the model reference case adjusted to reflect the Department of Finance conforming forecasts. These forecasts include California population figures dated May 2019, and U.S. real Gross Domestic Product (GDP) and civilian employment growth numbers dated April 2019.

However, not every cost or benefit from Chapters B and C can be directly correlated to the California economy in REMI, therefore this macroeconomic assessment does not account for all impacts. The valuation of cancer risk reduction, avoided premature mortality, and the social cost of CO_2, are excluded from the REMI analysis. The valuation of avoided premature mortality presented in Section B.4.b is based on willingness to pay,[150] which is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risks of dying in a year. As such, it is not related to a specific expenditure in the California economy and cannot be translated into REMI modeling. The social cost of CO_2 presented in Section B.4.c is a global metric and the portion of cost attributed to California cannot be estimated, so this is also excluded from REMI analysis.

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[149] Gov. Code, §§ 11346.3, 11346.36, ARTICLE 5. Public Participation: Procedure for Adoption of Regulations; Cal. Code Regs. tit. 1 §§ 2000-2004, ORDER OF ADOPTION; see also: http://dof.ca.gov/Forecasting/Economics/Major_Regulations/SB_617_Rulemaking_Documents/documents/Order_of_Adoption-1.pdf.

[150] U.S. EPA Science Advisory Board (U.S. EPA-SAB), An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction (June 2000), EPA-SAB-EEAC-00-013, https://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf.

2. Inputs of the Assessment

The estimated economic impacts of the Proposed Regulation and alternatives are sensitive to modeling assumptions. This section provides a summary of the assumptions used to determine the suite of policy variables that best reflect the macroeconomic impacts of the Proposed Regulation under the Baseline. The costs and savings of the Proposed Regulation estimated in the previous sections are translated into REMI variables and used as inputs for the macroeconomic analysis.[151]

Shore Power

Under the Proposed Regulation, various industries would face costs to install and maintain shore power equipment. The increases in costs faced by terminals and ports are input into REMI as an increase in production cost in the support activities for transportation industry (NAICS 488).[152] Increases in costs faced by vessel operators would initially be borne by the water transportation industry and would be passed on to all other industries that rely on water transportation. The increased costs faced by vessel operators are input into REMI as an increase in production cost in all REMI industries in proportion to each industries use of water transportation as an intermediate input.

Industries that provide services to install and maintain shore power equipment would see increases in demand for their services. While the manufacturing of shore power equipment is likely to occur out of state, and is therefore not included in the REMI modeling, installation and maintenance of shore power infrastructure and shore power equipment on some vessels would occur in California. Increases in demand for berth retrofits is modeled as an increase in exogenous final demand in the construction industry (NAICS 23) and increases in demand for vessel retrofits is modeled as an increase in exogenous final demand in the ship and boat building industry (NAICS 3366). Increased demand for maintenance of shore power equipment is modeled as an increase in exogenous final demand in the electrical equipment manufacturing industry (NAICS 3353).

As vessels visit California ports, the vessel operators would face increased costs for utilizing shore power equipment while ports and terminals would bear increased electricity costs. The vessels would also experience decreased costs associated with less fuel use. The costs and cost savings to vessels associated with visits to California are input into REMI as a change in production costs in all California industries in proportion to their use of water transportation as an intermediate input. The changes in demand for electricity and fuel are modeled as changes in exogenous final demand in the electric power generation, transmission and distribution industry (NAICS 2211) and the petroleum and coal products manufacturing industry (NAICS 324), respectively.

Electricity that is used for shore power is eligible for LCFS credits. The value of the LCFS credits will go to terminal operators and is modeled as a decrease in the production costs in

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[151] Refer to Appendix F: At Berth Macroeconomic Technical Methodology for a full list of REMI inputs for this analysis.

[152] REMI aggregates support activities for transportation with scenic and sightseeing transportation (NAICS 487, 488).

the support activities for transportation industry and an increase in production costs for the petroleum and coal products manufacturing industry.

Capture and Control System

Capture and control systems are also expected to be used for compliance with the Proposed Regulation. As described in Section A.1.e, barged-based capture and control and land-based capture and control are the most likely applications.

Vessel operators will face hourly costs when they visit California ports and utilize barge-based capture and control services. These costs are input into REMI as an increase in production costs for all industries in proportion to their use of water transportation as an intermediate input. The increased demand for barge activities is modeled as an increase in industry sales in the support activities for transportation industry.[153] To meet the demand for barge-capture and control, barge operators are expected to make investments to grow the fleet of barge capture and control systems. These investments are input into REMI as an increase in production costs to the support activities for transportation industry and includes investments for new barges, CARB required approvals for capture and control technology, performance testing, and other ongoing costs associated with barge operations.

Terminals would face costs to install and maintain land-based capture and control technologies. These costs are input into REMI as an increase in production costs for the support activities for transportation industry. Vessel operators also face costs when utilizing land-based capture and control that are modeled as increases in production costs for all industries that utilize water transportation as an intermediate input. The costs associated with infrastructure installation for land-side capture and control would also lead to an increase in demand in industries providing and installing equipment. While manufacturers of the equipment are anticipated to be located outside California, the installation of equipment would occur in California, and is modeled as an increase in exogenous final demand in the construction industry. The infrastructure projects for land-side capture and control would also require additional feasibility studies, engineering, and permitting. The increased demand for these items is input into REMI as an increase in exogenous final demand in the architectural, engineering, and related services industry (NAICS 5413).

Remediation Fees

The estimated remediation fees paid by terminals and vessels are similarly input into REMI as an increase in production costs in the support activities for transportation industry or for all industries in proportion to their use of water transportation as an intermediate good. As the remediation fees are required to be invested into projects benefiting affected communities, the remediation fee was modeled in REMI as an increase in local government spending.

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[153] Industry sales is used instead of exogenous final demand because 100% of the increases in barge services would be expected to occur in California.

Administration

The Proposed Regulation would require a number of reports and plans be generated by ports, terminals, and vessel operators. The increased costs for port and terminal plans are input into REMI as an increased production cost for the support activities for transportation industry, and the increased costs for vessel reporting are input into REMI as an increase in production cost to all industries that use water transportation as an intermediate good. The increased demand of report and plan preparation is input into REMI as an increase in exogenous final demand in the office administrative services industry (NAICS 5611) and the architectural, engineering, and related services industry. To implement and enforce the Proposed Regulation, to perform testing and approvals for new emission control technologies, and to cover local permitting needs, staff anticipates that CARB, CSLC, and local and federal agencies may need additional staff. The increases in staff are input into REMI as increases in state, local, and federal government employment, and state, local, and federal government spending is offset to reflect differences in CARB, CSLC, local agency, and federal government compensation relative to REMI's default compensation for state, local, and federal government employees. Additional costs and revenues to CARB are input as changes in state government spending.

State and Local Government Tax Impacts

As described in sections D.1 and D.2, the Proposed Regulation may impact state and local government tax revenue. These changes are modeled in REMI as a change in state and local government spending.

Health Impacts

The Proposed Regulation is also anticipated to reduce hospitalizations and emergency room visits through estimated reductions in emissions as described in section B.4.b. The cost-savings from reduced hospital and emergency room visits is input into REMI as a reduction in consumer spending on hospitals.

Summary

The categories of costs and corresponding changes in costs and demand described above are summarized in Table E1 below. Refer to Appendix F: At Berth Macroeconomic Technical Methodology for a full list of REMI inputs used for this analysis.

Table E1: California Industries Incurring Compliance Costs and Secondary Industries with changes in Demand by Source of Costs

Source of Compliance Costs	California Industries Incurring Compliance Costs	California Industries with Changes in Final Demand
Shore power berth retrofits and maintenance	Support activities for transportation (488)	Construction (23)
		Electrical equipment manufacturing (3353)
Shore power vessel retrofit and maintenance	All industries based on use of water transportation as an intermediate input (483)	Ship and boat building (3366)
Ongoing shore power labor and energy costs	All industries based on use of water transportation as an intermediate input (483), Support activities for transportation (488)	Electric power generation, transmission, and distribution (2211)
		Petroleum and coal products manufacturing (324)
		State and local government tax revenue changes
Barge based capture and control		Support activities for transportation (488)
		Architectural, engineering, and related services (5413)
		State government
Land based capture and control		Construction (23)
		Architectural, engineering, and related services (5413)
		State government
Remediation Fees		Local government
Administration		Architectural, engineering, and related services (5413)
	State, local, and federal government	Office administrative services; Facilities support services (5611, 5612)

3. Results of the Assessment

The REMI output provides the impact of the Proposed Regulation on the California economy, and is presented as the annual incremental change of the Proposed Regulation under the high risk scenario. The California economy is anticipated to grow through 2032, therefore, negative impacts reported here should be interpreted as a slowing of growth and positive impacts as an increase in the rate of growth resulting from the Proposed Regulation.

a. California Employment Impacts

Table E2 presents the impact of the Proposed Regulation on total employment in California across all industries and for impacts on employment in several select California industries. As modeled, the Proposed Regulation is anticipated to result in a relatively small decrease in total employment growth in most years of the assessment. There is a small, but positive, impact on jobs estimated in 2020 and 2022 associated with additional feasibility studies and vessel and berth retrofits. The majority of the positive impact in 2020 and the larger positive impacts to jobs in 2024 and 2026 are primarily due to increases in construction required for land-based capture and control for vessels. Overall, the change in total employment is small relative to the baseline employment for the California economy, being less than 0.02 percent an all years.

Table E2: Total California Employment Impacts (Proposed Regulation)

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Statewide	Change (%)	0.01	0.00	0.00	0.00	0.01	0.00	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change in Jobs	1767	-156	63	-89	3306	-765	5523	-2055	-1807	-2322	-2384	-2406	-2385
Select Industries														
Support activities for transportation (488)	Change (%)	0.00	0.00	-0.01	-0.02	-0.03	0.01	-0.01	-0.04	-0.05	-0.05	-0.06	-0.06	-0.07
	Change in Jobs	-3	-2	-14	-23	-36	6	-17	-53	-71	-71	-80	-86	-91
Construction (23)	Change (%)	0.07	0.00	0.00	-0.01	0.15	-0.01	0.28	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03
	Change in Jobs	860	-24	-41	-62	1750	-120	3140	-259	-304	-350	-343	-317	-281
Petroleum and coal products manufacturing (324)	Change (%)	0.01	0.00	0.00	0.00	0.01	-0.01	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change in Jobs	1	0	0	0	1	-1	2	-2	-2	-2	-2	-2	-2
Electric power generation, transmission and distribution (2211)	Change (%)	0.00	0.00	0.00	0.00	0.01	0.00	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change in Jobs	1	0	0	0	3	-1	5	-3	-2	-3	-3	-3	-3

b. California Business Impacts

Gross output is used as a proxy for business impacts because it is principally a measure of an industry's sale or receipts and tracks the quantity of goods or services produced in a given time period. Output growth, as defined in REMI, is the sum of output in each private industry and State and local government as it contributes to the State's GDP, and is affected by production cost and demand changes. As production cost increases or demand decreases, output is expected to contract, but as production costs decline or demand increases, industry will likely experience output growth.

Ports, terminals, and vessels incur compliance costs and will experience reductions in output. However industries that are involved in construction for shore power retrofits and providing capture and control services will see an increase in demand, which will increase output. These competing trends result in a net change in output growth on the economy and depends on the timing and magnitude of costs and increases in demand. Because one-time compliance costs are financed, the costs on the regulated ports, terminals, and vessels is spread over time, while the benefits to the supplying industries are concentrated in the years that services and equipment are needed.

Table E3 shows the annual change in California output growth. The results show a decrease in output of $585 million in 2032 for the overall California economy, which is small relative to the larger California economy, corresponding to a change of 0.01 percent. At the industry level, the support activities for transportation industry is estimated to have a decrease in output of $24 million in 2032. This represents the net impact to ports, terminals, and barge-based capture and control suppliers. The other industries are estimated to see decreases in output that are less than 0.03 percent.

In 2020, 2024, and 2026, the results show increases in overall statewide output. The results show that a significant proportion of the increase in output can be attributed to the construction industry, which also sees increases in output in 2020, 2024, and 2026 due to increased activity around capture and control infrastructure.

Table E3: Change in California Output Growth (Proposed Regulation)

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Statewide	Change (%)	0.01	0.00	0.00	0.00	0.01	0.00	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change (2019M$)	344	-36	4	-31	669	-178	1145	-464	-420	-543	-567	-581	-585
Select Industries														
Support activities for transportation (488)	Change (%)	0.00	0.00	-0.01	-0.02	-0.03	0.00	-0.01	-0.05	-0.06	-0.07	-0.07	-0.08	-0.08
	Change (2019M$)	-1	-1	-3	-5	-7	1	-4	-13	-17	-19	-21	-23	-24
Construction (23)	Change (%)	0.07	0.00	0.00	-0.01	0.15	-0.01	0.28	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03
	Change (2019M$)	144	-3	-6	-10	309	-19	567	-42	-52	-62	-63	-59	-54
Petroleum and coal products manufacturing (324)	Change (%)	0.01	0.00	0.00	0.00	0.01	-0.01	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change (2019M$)	5	-2	-2	-3	8	-6	14	-12	-12	-13	-13	-13	-13
Electric power generation, transmission and distribution (2211)	Change (%)	0.00	0.00	0.00	0.00	0.01	0.00	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change (2019M$)	1	0	0	0	3	-1	4	-3	-2	-2	-3	-3	-3

c. Impacts on Investment in California

Private domestic investment consists of purchases of residential and nonresidential structures and of equipment and software by private businesses and nonprofit institutions. It is used as a proxy for impacts on investments in California because it provides an indicator of the future productive capacity of the economy. Table E4 presents the change in gross private domestic investment growth in California under the Proposed Regulation.

The relative changes to growth private investment for the Proposed Regulation show a decrease of about $90 million in 2032, or about 0.02 percent of baseline private investment.

Table E4: Change in California Investment Growth (Proposed Regulation)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Change (%)	0.01	0.00	0.00	0.00	0.01	-0.01	0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02
Change (2019M$)	28	-4	-9	-16	39	-27	62	-59	-79	-97	-100	-97	-90

d. Impacts on Individuals in California

The Proposed Regulation will not impose direct costs on individuals in California. However, the compliance costs incurred by affected businesses will cascade through the economy and be passed-through to some extent to individuals.

One measure of this impact is the change in real personal income. Table E5 shows the annual change in real personal income across all individuals in California. In most years, the Proposed Regulation are estimated to result in a decrease in personal income growth. In 2032, total personal income growth decreases by $311 million or 0.01 percent. The change in personal income here can also be divided by the California population[154] to show the average or per capita impact on personal income. The largest negative impact occurs in 2027 and corresponds to about an $8 decrease in per capita income. This follows a year with increases in per capita income growth corresponding to an $8 increase. Overall, these changes are trivial compared to the average per capita income of $70,000 estimated by the REMI model in the same two years.

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[154] The population forecast used to construct per capita income differs slightly from the DOF baseline forecast due to demographic changes estimated by the REMI model as a result of the Proposed Regulation.

Table E5: Change in Personal Income Growth (Proposed Regulation)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Change (%)	0.00	0.00	0.00	0.00	0.01	-0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Change (2019M$)	109	-50	-21	-37	200	-161	338	-333	-219	-280	-290	-302	-311
Change in Personal Income Per Capita (2019$)	2.70	-1.22	-0.50	-0.88	4.80	-3.82	7.98	-7.80	-5.09	-6.46	-6.64	-6.88	-7.03

e. *Impacts on Gross State Product (GSP)*

GSP is the market value of all goods and services produced in California and is one of the primary indicators used to gauge the health of an economy. Under the Proposed Regulation, GSP growth is anticipated to decline slightly as a result of the increased compliance costs. In 2032, the decrease amounts to 0.01 percent of baseline GSP growth.

Table E6: Change in Gross State Product Growth (Proposed Regulation)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Change (%)	0.01	0.00	0.00	0.00	0.01	0.00	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Change (2019$)	179	-18	6	-12	351	-90	599	-240	-211	-278	-290	-296	-297

f. *Creation or Elimination of Businesses*

The REMI model cannot directly estimate the creation or elimination of businesses. Changes in jobs and output for the California economy described above can be used to understand some potential impacts. The overall jobs and output impacts are small relative to the total California economy, about 0.01 percent. However, impacts in some sectors are larger or occur at different times, as described in the previous sections.

Reductions in output could indicate elimination of businesses. Conversely, increased output within an industry could signal the potential for additional business creation if existing businesses cannot accommodate all future demand. There is no threshold that identifies the creation or elimination of a business. Based on the modeling of output growth, the construction industry sees increased output in several years but this output is not sustained so will likely not lead to long term business creation.

The support activities for transportation industry, representing ports, terminals, and barge operators, sees a net decreases in output growth. Ports and terminals are large, and while they face compliance costs, it is unlikely that they will be eliminated. Staff expects the Proposed Regulation to provide substantial incentives for barge operators. There are currently two companies providing capture and control services to container vessels at the Ports of Los Angeles and Long Beach. However, to meet demand for capture and control services at California ports, Staff have estimated approximately 12 more barges would need to be deployed prior to 2020 and an additional 32 barges would need to be deployed prior to 2024, likely resulting in the expansion of businesses in the transportation support industries.

g. Incentives for Innovation

The Proposed Regulation can require and provide impetus for vessel and terminal operators and ports to pursue the cleanest available technologies to reduce emissions at berth. Currently there are two CARB approved emission control strategies (shore power and barge-based capture and control system) to assist with compliance. Approximately 2,500 additional vessels visits annually will be required to reduce emissions under the Proposed Regulation. This need is expected to create a market for additional strategies to assist in compliance and to accelerate development of emission reduction technologies in marine applications that could compete with the available barge-based emissions control systems and shore power. Technologies are available that can be adapted to reduce ocean-going vessel auxiliary engine emissions, and potentially auxiliary boiler exhaust, that will move vessels toward CARB's long-term goal of zero and near-zero emissions to ensure compliance with the Proposed Regulation. This includes, but is not limited to advanced boiler and engine technologies, marine exhaust gas scrubbing systems, diesel emission control devices with selective catalytic reduction (SCR) after-treatment, distributed generation equipment, non-grid based shore power, alternative fuels and capture and control technologies adapted to land-based systems as described in CARB's Draft Technology Assessment: Ocean-going vessels (May 2018).[155]

h. Competitive Advantage or Disadvantage

The Proposed Regulation increases costs to California ports and terminals, and the vessels that visit them. Cargo owners and international cargo transport delivery companies rely on sophisticated proprietary models and factors to guide decisions on where to ship goods. The factors include access to consumer markets and intermodal transportation networks; reliability and velocity of transport modes; port and trans-loading infrastructure; the overall efficiency of the supply chain as it is impacted by the availability of labor; congestion delays and other impediments; and costs, including compliance costs for all regulations. To date, the available data and research has been insufficient to quantify the impact on the competitive advantage or disadvantage of the Proposed Regulation as it relates to cargo diversion.

Quantifying the potential for the Proposed Regulation to cause cargo diversion requires either a detailed understanding of how increased regulatory costs would impact each beneficial cargo owner's use of a specific port; or would require causal estimates from historical data to understand the contributing factors, and to estimate the impact of regulatory costs on cargo

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[155] California Air Resources Board, DRAFT TECHNOLOGY ASSESSMENT: OCEAN-GOING VESSELS (May 2018), https://ww3.arb.ca.gov/msprog/tech/techreport/ogv_tech_report.pdf.

diversion. CARB staff directly engaged industry stakeholders for their experience or data, and found that a company's decision to divert cargo from one port to another is complex and unique to individual businesses. CARB staff was unable to obtain information on business level responses to regulatory costs due to the highly competitive nature of the freight industry.

In addition, CARB staff did not find empirical research that focused on the impact of regulatory costs on cargo diversion. A number of studies have explored the relationship between general cost increases and the likelihood of cargo diversion. These studies found that there is a very wide range of estimates for how increased costs may impact cargo volumes,[156,157,158] that the estimates are highly uncertain, and that these responses may change markedly in the span of only several years due to the dynamics of industry and global economics.

One case study on the potential impact of a container fee suggested that cargo diversion is unlikely for modest per TEU cost increases, up to $30 per TEU.[159] To put this into context, the Proposed Regulation would add additional costs of approximately $1.30 per TEU in 2030 for container and reefer vessels.[160] Although the per unit cost of the Proposed Regulation for other vessels types are not directly comparable to the TEU statistic, for illustrative purposes they are: approximately $5.25 per passenger for cruise vessels, approximately $7.50 per automobile for ro-ros, and less than $0.01 per gallon for tankers.[161]

4. Summary and Agency Interpretation of the Assessment Results

As modeled, CARB estimates the Proposed Regulation will have a negligible impact on the California economy. The economic modeling results show that the support activities for transportation industry will, on net, see small decreases in employment and output as it faces higher compliance costs. However, businesses within the support activities for transportation industry, such as barge operators may see increases in demand. In addition, industries that provide services to ports, terminals, and vessels, such as construction, are expected to see increases in demand in certain years that would balance out the impacts to the California economy.

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[156] Leachman, Robert C., (2005) "Final Report: Port and Modal Elasticity Study," http://www.freightworks.org/Documents/Port%20and%20Modal%20Elasticity%20Study.pdf.

[157] Leachman, Robert C., (2010) "Final Report: Port and Modal Elasticity Study, Phase II," http://www.freightworks.org/DocumentLibrary/Port%20and%20Modal%20Elasticity%20Study%20Phase%20II%20-%20Final%20Report.pdf

[158] Corbett, James J., James J. Winebrake, and Erin Green, (2006) "Cargo on the Move through California: Evaluating Container Fee Impacts on Port Choice," https://www.nrdc.org/sites/default/files/air_06081401a.pdf. Accessed July 23, 2019.

[159] Corbett, James J., James J. Winebrake, and Erin Green, (2006) "Cargo on the Move through California: Evaluating Container Fee Impacts on Port Choice," https://www.nrdc.org/sites/default/files/air_06081401a.pdf. Accessed July 23, 2019.

[160] Appendix D: Development of Cost Impacts to Individuals for Standardized Regulatory Impact Assessment.

[161] Appendix D: Development of Cost Impacts to Individuals for Standardized Regulatory Impact Assessment.

F. ALTERNATIVES

1. Alternative 1: Shore Power Only Compliance Pathway

Alternative 1 provides a scenario that could achieve additional emission reduction benefits beyond those associated with the Proposed Regulation for some, but not all, pollutants. Under this alternative, the only allowable strategy to reduce at berth emissions would be the use of shore power for all vessel visits to California (above the same terminal vessel visit thresholds as the Proposed Regulation). Alternative 1 would eliminate the option for other compliance pathways including capture and control systems. Other aspects of the Proposed Regulation would remain unchanged including the phase-in dates for each vessel type.

CARB staff identified and chose to evaluate this alternative because it would rely exclusively on shore power, the most demonstrated, proven, and effective technology to reduce vessel emissions at berth. With over eight years of experience in California connecting vessels at berth to the electrical grid, vessel fleets, ports/terminal operators, and labor have the most extensive experience with this technology. Shore power also offers significantly greater reductions in GHG emissions than all other known alternatives.

a. Costs

The total direct cost to vessel owners and operators is the summation of the cost of the shore power equipment installation on the vessel, vessel modifications, labor, maintenance, electricity, and reporting. For ports and terminals, the direct costs include shore power infrastructure, maintenance, plan development, and reporting, less any fuel cost savings from using shore power rather than fuel. The main difference in cost categories between Alternative 1 and the Proposed Regulation is the number of vessels that need to have shore power installed and additional berths that need to have shore power installed as described below.

From 2020-2032, Alternative 1 is estimated to cost $1.4 billion more than the Proposed Regulation. This is due to the significantly higher costs for the ro-ro vessel category at $1.3 billion and slightly higher costs for the tanker vessel category at $140 million. These higher costs are marginally offset by lower costs for the container and reefer vessel category at $21 million. The cost for the cruise category is the same as that for the Proposed Regulation as shore power is the only option for cruise vessels.

The higher cost for the ro-ro vessel category is attributed to installing shore power on 261 vessels and installing infrastructure at 21 berths. The Proposed Regulation assumed that barge- or land-based capture and control systems would be used for ro-ro vessel visits, which does not requires vessel modifications. Additionally, only three berths were assumed to use a land-based capture and control system compared to installing shore power. The assumed cost for a vessel retrofit and shore power infrastructure varies depending upon the vessel category (See Appendix A, Table XII). Although vessel operators would not have a cost for using the barge-based capture and control system under Alternative 1, the costs for shore power is significantly higher.

The cost for the tanker vessel category for Alternative 1 includes installing shore power rather than installing land-based capture and control systems, which have a higher cost due to the need for cranes and crane support structures. While the cost to install shore power at 30 berths is lower than the costs associated with installing land-based capture and control systems, the total costs for the tanker vessel category are higher because of the need to install shore power on 446 tanker vessels.

The cost for container and reefer vessels in Alternative 1 compared to the Proposed Regulation is due to the difference between installing shore power on five additional vessels and the cost of the visits that would be controlled by a barge-based capture and control system under the Proposed Regulation.

For Alternative 1, additional cost savings to vessel operators would occur due to avoided distillate fuel usage in the auxiliary engines that would no longer operate as long at berth. Ports and terminals are assumed to take credit from the sale of LCFS credits when vessels are using electricity instead of distillate fuels. Similar to the Proposed Regulation, staff included an annual industry growth factor to account for increased freight volume through ports through 2032, as described in Chapter C.3.d.ii.

Table F1 summarizes annual and total direct costs to ports, terminals and vessel operators by vessel category for Alternative 1 and Table F2 shows the cost differential between Alternative 1 and the Proposed Regulation (Table C12). Total direct net costs include shore power infrastructure at berths, installing shore power on vessels, maintenance, labor, shore power energy costs, and fuel cost savings.

Table F1: Annual and Total Projected Net Costs for Alternative 1 from 2020 – 2032

Year	Container/Reefer	Cruise	Ro-Ro	Tankers	Bulk/General Cargo	Total
2020	$8,869,000	$13,706,000	$138,000	$10,640,000	$0	$33,353,000
2021	$14,169,000	$15,504,000	$138,000	$11,936,000	$209,000	$41,956,000
2022	$14,404,000	$15,990,000	$498,000	$25,413,000	$209,000	$56,514,000
2023	$14,594,000	$16,652,000	$396,000	$25,415,000	$209,000	$57,266,000
2024	$15,107,000	$17,220,000	$147,346,000	$60,465,000	$209,000	$240,346,000
2025	$15,747,000	$17,836,000	$149,544,000	$60,764,000	$209,000	$244,100,000
2026	$16,434,000	$18,457,000	$153,355,000	$254,487,000	$209,000	$442,941,000
2027	$16,897,000	$19,107,000	$157,449,000	$244,402,000	$209,000	$438,064,000
2028	$17,307,000	$19,761,000	$160,723,000	$246,373,000	$209,000	$444,373,000
2029	$17,752,000	$20,439,000	$164,039,000	$230,735,000	$209,000	$433,173,000
2030	$18,234,000	$21,149,000	$167,490,000	$232,407,000	$209,000	$439,488,000
2031	$18,833,000	$21,863,000	$170,869,000	$234,266,000	$209,000	$446,039,000
2032	$19,677,000	$22,614,000	$174,540,000	$236,386,000	$209,000	$453,426,000
Total	$208,025,000	$240,298,000	$1,446,525,000	$1,873,688,000	$2,503,000	$3,771,038,000

Table F2: Differential in Annual and Total Projected Net Costs for Alternative 1 Compared to the Proposed Regulation from 2020 – 2032

Year	Container/Reefer	Cruise	Ro-Ro	Tankers	Bulk/General Cargo	Total
2020	$614,159	$0	$0	-$4,467,402	$0	-$3,853,242
2021	-$1,469,638	$0	$0	-$4,467,402	$0	-$5,937,040
2022	-$1,522,256	$0	$0	-$18,080,817	$0	-$19,603,073
2023	-$1,578,348	$0	$0	-$18,080,817	$0	-$19,659,165
2024	-$1,637,984	$0	$145,855,177	-$26,884,940	$0	$117,332,254
2025	-$1,700,703	$0	$133,428,643	-$26,955,004	$0	$104,772,936
2026	-$1,798,347	$0	$136,805,588	$68,421,479	$0	$203,428,721
2027	-$1,842,205	$0	$140,420,387	$49,595,657	$0	$188,173,839
2028	-$1,890,211	$0	$143,279,071	$49,798,613	$0	$191,187,474
2029	-$1,942,266	$0	$146,202,970	$18,552,717	$0	$162,813,421
2030	-$1,998,313	$0	$149,253,155	$17,962,697	$0	$165,217,539
2031	-$2,057,699	$0	$152,220,952	$17,330,737	$0	$167,493,990
2032	-$2,156,033	$0	$155,456,349	$16,993,783	$0	$170,294,100
Total	-$20,979,842	$0	$1,302,922,293	$139,719,302	$0	$1,421,661,753

b. Benefits

Emissions reduction estimates for Alternative 1 were developed according to the methodology described in Chapter B.1.a. For Alternative 1, emissions reduction estimates were based on the assumption that all regulated vessels would comply using shore power. The emissions reductions while vessels are shore powered would be 100 percent for PM2.5, DPM, NOx and ROG and 65 percent for GHGs.

Table F3 summarizes total annual PM2.5, DPM, NOx, GHG, and ROG emissions reductions projected under Alternative 1 and Table F4 summarizes the differential in the emissions reductions under Alternative 1 compared to the Proposed Regulation. Alternative 1 would result in fewer PM2.5 emissions reductions (75 tons over the 12 year period analyzed) compared to the Proposed Regulation because the tanker boilers used to power the product pumps cannot operate on shore power. Therefore, the tanker boiler PM2.5 emissions would not be reduced. Alternative 1 compared to the Proposed Regulation would result in slightly greater emissions reductions of DPM (24 tons), NOx (54 tons), and ROG (63 tons) in this twelve-year period. However, GHG reductions would be significantly greater (by about 488,000 metric tons) under Alternative 1 because shore power achieves higher reductions of GHGs from the auxiliary engines compared to the capture and control system. For DPM, NOx, GHG, and ROG, the additional reductions that would be achieved from using shore power instead of running auxiliary engines would be higher than the reductions lost from not controlling the tanker boilers.

Table F3: Annual and Total Emission Reductions Resulting from Alternative 1 from 2021 – 2032 (Tons/Year)

Year	PM2.5 Emission Reductions (Tons)	DPM Emission Reductions (Tons)	NOx Emission Reductions (Tons)	GHG Emission Reductions (Metric Tons)	ROG Emission Reductions Proposed Regulation (Tons)
2021	12	13	819	34,906	38
2022	13	14	855	36,643	40
2023	15	17	1,013	43,750	47
2024	16	17	1,058	45,877	50
2025	21	23	1,393	60,669	66
2026	22	24	1,451	63,514	69
2027	28	30	1,815	80,245	87
2028	29	32	1,886	83,584	91
2029	37	40	2,334	104,458	113
2030	38	41	2,411	108,455	118
2031	39	43	2,432	111,925	121
2032	40	44	2,218	115,514	125
Total	311	338	19,684	889,540	964

Table F4: Differential in the Annual and Total Emission Reductions for Alternative 1 and the Proposed Regulation from 2021 – 2032 (Tons/Year)

Year	PM2.5 Emission Reductions (Tons)	DPM Emission Reductions (Tons)	NOx Emission Reductions (Tons)	GHG Emission Reductions (Metric Tons)	ROG Emission Reductions Proposed Regulation (Tons)
2021	0	0	10	2,467	3
2022	0	0	10	2,526	3
2023	0	1	11	2,731	2
2024	0	0	12	2,828	3
2025	1	1	68	17,941	7
2026	1	1	73	19,407	8
2027	-8	2	1	48,877	4
2028	-9	3	-1	50,793	5
2029	-14	4	-24	82,385	7
2030	-15	4	-26	84,864	8
2031	-16	4	-34	86,124	7
2032	-16	4	-44	87,373	8
Total	-75	24	54	488,316	63

The estimation methodologies described in Chapter B were used to quantify avoided cardiopulmonary mortality, avoided hospital admissions, and avoided emergency room visits that would be expected to result from Alternative 1. Tables F5 and F6 summarize the avoided cardiopulmonary mortality, avoided hospital admissions and avoided emergency room visits for the Proposed Regulation and Alternative 1. Staff estimated that Alternative 1 would result in approximately 3 fewer avoided cases of cardiopulmonary mortality, 2 fewer avoided hospital admissions, and 9 fewer avoided emergency room visits compared to the Proposed Regulation.

Table F5: Incremental Regional and Statewide Avoided Cardiopulmonary Mortality, Hospital Admissions and Emergency Room Visits from 2021 – 2032 under the Proposed Regulation, Relative to the Baseline

Air Basin	Avoided Cardiopulmonary Mortality	Avoided Hospital Admissions	Avoided Emergency Room Visits
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
San Diego County	7 (6 - 9)	2 (0 - 4)	3 (2 - 4)
San Francisco Bay	34 (26 - 42)	11 (1 - 20)	19 (12 - 26)
San Joaquin Valley	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
South Central Coast	2 (1 - 2)	0 (0 - 1)	1 (1 - 1)
South Coast	227 (178 - 278)	75 (10 - 138)	116 (74 - 159)
Total	271 (212 - 331)	88 (11 - 163)	140 (88 - 191)

Table F6: Incremental Regional and Statewide Avoided Cardiopulmonary Mortality, Hospital Admissions and Emergency Room Visits from 2021 – 2032 under Alternative 1, Relative to the Baseline

Air Basin	Avoided Cardiopulmonary Mortality	Avoided Hospital Admissions	Avoided Emergency Room Visits
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
San Diego County	8 (6 - 10)	2 (0 - 4)	3 (2 - 5)
San Francisco Bay	33 (26 - 40)	11 (1 - 19)	19 (12 - 25)
San Joaquin Valley	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
South Central Coast	2 (2 - 3)	0 (0 - 0)	1 (1 - 1)
South Coast	218 (170 - 266)	73 (9 - 135)	114 (72 - 156)
Total	262 (205 - 320)	86 (11 - 160)	137 (87 - 188)

Health benefits in Alternative 1 were valued using the same methodology described in Section B.4 for the Proposed Regulation. The total value of health benefits under Alternative 1 is included in Table F7. The Proposed Regulation provides a higher valuation of health benefits at $2.64 billion, as shown in Table B9 compared to Alternative 1 at $2.56 billion.

Table F7: Valuation of Health Benefits for 2021 – 2032, Relative to the Baseline for Alternative 1

Outcome	Value of Health Benefits (2019$)
Avoided Cardiopulmonary Mortality	$2,550,309,000
Avoided Hospital Admissions	$4,707,000
Avoided ER Visits	$115,000
Total	**$2,555,131,000 ($2.56 billion)**

2. Economic Impacts

The impacts described in Section F.1 are input into REMI to assess the macroeconomic impact of Alternative 1 and are summarized in Table F8. As discussed in Section F.1, staff anticipates that Alternative 1 would result in higher costs to vessel owners, ports, and terminals overall. For ro-ro vessels, the cost of implementing shore power for all vessel visits over the terminal visit thresholds would be much higher than implementing capture and control technology, primarily due to high vessel retrofit costs. Ports and terminals where ro-ro vessels visit would also have higher costs due to infrastructure costs to install shore power at several terminals. Container and reefer vessels would incur slightly lower costs under Alternative 1 than under the Proposed Regulation because the cost for using the barge-based capture and control systems is slightly higher. For cruise vessels, the cost is the same because the only technically feasible control option for cruise vessels under the Proposed Regulation is shore power.

Alternative 1 is estimated to have larger impacts on the California economy than the Proposed Regulation. In 2032, the impacts of Alternative 1 are about twice those of the Proposed Regulation. However, Alternative 1 is estimated to have a minimal impact on the California economy overall, relative to the baseline. The results of the analysis show a 0.02 to 0.03 percent decreases in growth of the various economic indicators in 2032.

Alternative 1 would increase demand for shore power technology, thus positively impacting businesses that develop and manufacture shore power equipment. It would reduce demand for capture and control technology for vessels at berth in California, which would negatively impact capture and control technology developers, equipment manufacturers, and tug vessel operators.

Table F8: Estimated Change in Economic Indicators for Alternative 1 Compared to the Baseline

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Employment	Change (%)	0.01	0.00	0.00	0.00	0.02	-0.01	0.00	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	Jobs	1600	-300	-400	-500	5300	-2300	0	-4000	-4100	-4200	-4300	-4300	-4300
Output	Change (%)	0.01	0.00	0.00	0.00	0.02	-0.01	0.00	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	Change (2016M$)	308	-69	-81	-105	1076	-531	-76	-965	-1018	-1077	-1117	-1144	-1163
Private Investment	Change (%)	0.01	0.00	0.00	-0.01	0.01	-0.02	-0.02	-0.04	-0.04	-0.04	-0.04	-0.03	-0.03
	Change (2016M$)	25	-7	-16	-22	57	-71	-83	-167	-187	-187	-180	-169	-157
Personal Income	Change (%)	0.00	0.00	0.00	0.00	0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	Change (2016M$)	97	-58	-46	-55	293	-360	-185	-543	-518	-537	-559	-576	-591
GSP	Change (%)	0.01	0.00	0.00	0.00	0.02	-0.01	0.00	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	Change (2016M$)	159	-36	-40	-53	559	-271	-31	-486	-508	-532	-549	-560	-567

3. Cost-Effectiveness

Cost-effectiveness is a measure of the cost of an emissions reduction project or program per ton of expected emissions reduction. There are multiple approaches to calculating cost-effectiveness. For the Proposed Regulation and Alternatives, staff used a cost-effectiveness method provided in the Carl Moyer Guidelines Appendix C.[162] The Carl Moyer cost-effectiveness metric is useful because it is widely used and therefore, straightforward to compare between programs, and reflects the emissions reductions of multiple pollutants (NOx, PM2.5 and ROG). The cost effectiveness (in $/weighted ton) is calculated by dividing the cost over a period of time by the weighed emissions reductions (in tons per year or TPY) over the same period of time using the following equation.

$$Cost - Effectiveness = \frac{Net\ Direct\ Costs}{[NOx\ (TPY)\ +\ (20\ *\ PM2.5)(\mathrm{TPY})\ + \mathrm{ROG}\ (\mathrm{TPY})]}$$

Net Direct Costs = Direct Costs – Cost Savings – LCFS Revenue
NOx = Cumulative tons of NOx emission reductions
ROG = Cumulative tons of ROG emission reductions
PM2.5 = Cumulative tons of PM2.5 emission reductions

Cost-effectiveness for the Proposed Regulation and Alternative 1 was calculated using the metrics described above and is summarized in Table F9. Staff estimated that Alternative 1 would be less cost-effective than the Proposed Regulation due to the higher direct costs to industry.

Table F9: Cost-Effectiveness of the Proposed Regulation and Alternative 1 from 2020 – 2032

Metric	Carl Moyer Methodology ($/weighted ton)
Proposed Regulation	$83,159
Alternative 1	$140,364
Difference in Cost-Effectiveness	$57,205

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[162] California Air Resources Board The Carl Moyer Program Guidelines, 2017 Revisions, Appendix C. Available at https://ww3.arb.ca.gov/msprog/moyer/guidelines/current.htm

4. Reason for Rejecting

Alternative 1 was rejected because it has significantly higher costs and is less cost effective to implement than the Proposed Regulation. Also, a 100 percent shore power mandate would not be as practical for all vessel types as the Proposed Regulation's allowance for vessel and terminal operators to choose the most favorable compliance option for their business interests and industry practices. For vessels that visit California ports infrequently, making expensive vessel modifications would not be economical, potentially resulting in an increased risk of cargo diversion for these vessels. Installing shore power systems at berths or terminals with little utilization would be costly and achieve minimal additional emission reductions. While container vessel costs are lower for Alternative 1 (see Table F2), CARB's experience with the Existing Regulation has shown that there are situations where capture and control systems are needed for compliance. These situations include vessel that are not shore power capable, terminals where shore power is not available due to construction, or periods of peak vessel visit activity.

In addition, Alternative 1 would not support control of tanker boilers, which contribute the majority of PM2.5 and GHG emissions from vessels at berth because grid based shore power can only replace the operations of the auxiliary engines. Tanker vessel operators have raised concerns to CARB staff regarding the cost, safety, and operational feasibility of installing shore power infrastructure and utilizing shore power for vessels while on- and off-loading petroleum products. Oil tankers were purpose-built to use shore power at a berth in Long Beach, and have been doing so safely and successfully for years. However, since the rest of the oil tanker fleet has not been constructed specifically to use shore power, staff responded to oil industry concerns by including alternatives in the Proposed Regulation.

5. Alternative 2: Proposed Regulation Excluding Ro-Ro Vessels

Alternative 2 is identical to the Proposed Regulation, with the exception that it does not include emission control requirements for ro-ro vessels. However, they would still have reporting requirements. Under Alternative 2, vessel owners/operators would still have the flexibility to use shore power, a capture and control system, or other methods to reduce onboard emissions, subject to CARB approval. By removing ro-ro vessels under Alternative 2, 261 fewer vessels and over 870 fewer visits to California ports would be subject to emission control requirements, compared with the Proposed Regulation.

CARB staff identified and chose to evaluate this alternative because ro-ros are one of the two new vessel types that would be controlled under the Proposed Regulation. However, compared to tankers (the other new vessel type), emissions from ro-ro vessels at berth are significantly less. Staff analyzed how much removing the proposed controls on ro-ro vessels would affect the overall costs and benefits of the regulation.

a. Costs

Similar to the Proposed Regulation, Alternative 2 would allow for multiple emission control strategies, including shore power and barge or land-based capture and control systems.

Table F10 summarizes the total estimated net costs to ports, terminals and vessel operators that would result from Alternative 2. Costs include shore power infrastructure at berths, installing shore power on vessels, maintenance, labor, shore power energy costs, fuel cost savings, and administrative costs including reporting costs for ro-ro vessels. From 2020 through 2032, Alternative 2 would result in total costs that are approximately $141 million lower than the Proposed Regulation, due to fewer vessel visits that would be subject to emission control requirements compared with the Proposed Regulation.

Table F10: Annual and Total Projected Net Costs for Alternative 2 from 2020 – 2032

Year	Container/Reefer	Cruise	Ro-Ro	Tankers	Bulk/General Cargo	Total
2020	$8,255,000	$13,706,000	$0	$15,107,000	$0	$37,068,000
2021	$15,639,000	$15,504,000	$234,000	$16,403,000	$209,000	$47,989,000
2022	$15,926,000	$15,990,000	$241,000	$43,494,000	$209,000	$75,859,000
2023	$16,172,000	$16,652,000	$248,000	$43,496,000	$209,000	$76,777,000
2024	$16,745,000	$17,220,000	$255,000	$87,350,000	$209,000	$121,779,000
2025	$17,448,000	$17,836,000	$263,000	$87,719,000	$209,000	$123,474,000
2026	$18,232,000	$18,457,000	$270,000	$186,066,000	$209,000	$223,233,000
2027	$18,740,000	$19,107,000	$276,000	$194,806,000	$209,000	$233,137,000
2028	$19,197,000	$19,761,000	$283,000	$196,575,000	$209,000	$236,025,000
2029	$19,694,000	$20,439,000	$289,000	$212,182,000	$209,000	$252,813,000
2030	$20,233,000	$21,149,000	$296,000	$214,444,000	$209,000	$256,329,000
2031	$20,890,000	$21,863,000	$303,000	$216,935,000	$209,000	$260,200,000
2032	$21,833,000	$22,614,000	$310,000	$219,392,000	$209,000	$264,358,000
Total	$229,004,000	$240,298,000	$3,268,000	$1,733,969,000	$2,503,000	$2,209,042,000

b. Benefits

Emissions reduction estimates for Alternative 2 were developed according to the methodology described in Chapter B.1.b and emissions reductions from ro-ro vessels were removed from the analysis.[163]

Table F11 summarizes total annual PM2.5, DPM, NOx, GHG, and ROG emission reductions projected under Alternative 2 and Table F12 summarizes the differential in the emissions reductions under Alternative 2 compared to the Proposed Regulation. Cumulatively from 2021 through 2032, Alternative 2 compared to the Proposed Regulation would result in slightly fewer emissions reductions of PM2.5 (32 tons), DPM (34 tons), NOx (2,038 tons), and ROG (83 tons). Alternative 2 would result in 24,194 additional metric tons of GHG emissions reductions relative to the Proposed Regulation. This is because ro-ro vessels are anticipated to control emissions from a majority of visits using capture and control systems, which may result in a minor GHG increase due to powering the control system and running the vessel's auxiliary engines, even while PM2.5, DPM, NOx, and ROG emissions decrease.

Table F11: Annual and Total Emission Reductions Resulting from Alternative 2 from 2021 – 2032 (Tons/Year)

Year	PM2.5 Emission Reductions (Tons)	DPM Emission Reductions (Tons)	NOx Emission Reductions (Tons)	GHG Emission Reductions (Metric Tons)	ROG Emission Reductions (Tons)
2021	12	13	809	32,439	35
2022	13	14	845	34,117	37
2023	15	16	1,002	41,019	45
2024	16	17	1,046	43,049	47
2025	17	18	1,092	45,169	49
2026	17	19	1,129	47,007	51
2027	32	24	1,562	34,335	73
2028	34	25	1,631	35,825	76
2029	47	31	2,098	25,176	95
2030	49	33	2,172	26,766	99
2031	50	34	2,208	29,051	102
2032	52	35	1,997	31,466	106
Total	354	280	17,592	425,418	817

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[163] California Air Resources Board, *DRAFT: 2018/2019 Update to Inventory for Ocean-Going Vessels: Methodology and Results, (January, 2019)*, https://www.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf.

Table F12: Differential in the Annual and Total Emission Reductions for Alternative 2 and the Proposed Regulation from 2021 – 2032 (Tons/Year)

Year	PM2.5 Emission Reductions (Tons)	DPM Emission Reductions (Tons)	NOx Emission Reductions (Tons)	GHG Emission Reductions (Metric Tons)	ROG Emission Reductions Proposed Regulation (Tons)
2021	0	0	0	0	0
2022	0	0	0	0	0
2023	0	0	0	0	0
2024	0	0	0	0	0
2025	-3	-4	-233	2,441	-10
2026	-4	-4	-249	2,900	-10
2027	-4	-4	-252	2,967	-10
2028	-4	-4	-256	3,034	-10
2029	-4	-5	-260	3,103	-11
2030	-4	-4	-265	3,175	-11
2031	-5	-5	-258	3,250	-12
2032	-4	-5	-265	3,325	-11
Total	-32	-34	-2,038	24,194	-84

The estimation methodologies described in Chapter B were used to quantify avoided cardiopulmonary mortality, avoided hospital admissions, and avoided emergency room visits that would be expected to result from Alternative 2. Tables F13 and F14 summarize the avoided cardiopulmonary mortality, avoided hospital admissions and avoided emergency room visits for the Proposed Regulation and Alternative 2. Staff estimated that Alternative 2 would result in approximately 21 fewer avoided cases of cardiopulmonary mortality, 5 fewer avoided hospital admissions, and 8 fewer avoided emergency room visits compared to the Proposed Regulation.

Table F13: Incremental Regional and Statewide Avoided Cardiopulmonary Mortality, Hospital Admissions and Emergency Room Visits from 2021 – 2032 under the Proposed Regulation, Relative to the Baseline

Air Basin	Avoided Cardiopulmonary Mortality	Avoided Hospital Admissions	Avoided Emergency Room Visits
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
San Diego County	7 (6 - 9)	2 (0 - 4)	3 (2 - 4)
San Francisco Bay	34 (26 - 42)	11 (1 - 20)	19 (12 - 26)
San Joaquin Valley	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
South Central Coast	2 (1 - 2)	0 (0 - 1)	1 (1 - 1)
South Coast	227 (178 - 278)	75 (10 - 138)	116 (74 - 159)
Total	271 (212 - 331)	88 (11 - 163)	140 (88 - 191)

Table F14: Incremental Regional and Statewide Avoided Cardiopulmonary Mortality, Hospital Admissions and Emergency Room Visits from 2021 – 2032 under Alternative 2, Relative to the Baseline

Air Basin	Avoided Cardiopulmonary Mortality	Avoided Hospital Admissions	Avoided Emergency Room Visits
North Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
Sacramento Valley	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
San Diego County	3 (2 - 4)	0 (0 - 2)	1 (1 - 2)
San Francisco Bay	31 (24 - 38)	10 (1 - 19)	18 (11 - 24)
San Joaquin Valley	1 (1 - 1)	0 (0 - 0)	0 (0 - 0)
South Central Coast	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
South Coast	215 (168 - 262)	72 (9 - 133)	113 (71 - 154)
Total	250 (195 - 305)	83 (11 - 154)	132 (83 - 180)

Health benefits in Alternative 2 were valued using the same methodology described in section B.4 for the Proposed Regulation. The total value of health benefits under Alternative 2 is included in Table F15. The Proposed Regulation provides a higher valuation of health benefits at $2.64 billion as shown in Table B9 compared to Alternative 2 at $2.44 billion.

Table F15: Valuation of Health Benefits for 2021 – 2032 under Alternative 2, Relative to the Baseline

Outcome	Value of Health Benefits (2019$)
Avoided Cardiopulmonary Mortality	$2,431,282,000
Avoided Hospital Admissions	$4,513,000
Avoided ER Visits	$110,000
Total	$2,435,904,000 ($2.44 billion)

c. Economic Impacts

The impacts described in Sections F.5.b and F.5.c are input into REMI to assess the macroeconomic impact of Alternative 2 and are summarized in Table F16. As discussed in Section F.5.b, ro-ro vessels would not be subject to emission control requirements under Alternative 2. Therefore, ports, terminals, and ro-ro vessel operators would not incur direct costs to comply with emission control requirements for ro-ro vessels, and as a result, Alternative 2 has slightly smaller economic impacts than the Proposed Regulation. Alternative 2 is estimated to have a minimal impact on the California economy, relative to the baseline. The results of the analysis show a 0.01 to 0.02 percent decrease in growth of the various economic indicators in 2032.

Table F16: Estimated Change in Economic Indicators for Alternative 2 Compared to the Baseline

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Employment	Change (%)	0.01	0.00	0.00	0.00	0.01	0.00	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Jobs	1800	-200	100	-100	3300	-800	5500	-2000	-1800	-2300	-2400	-2400	-2400
Output	Change (%)	0.01	0.00	0.00	0.00	0.01	0.00	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change (2019M$)	344	-37	2	-32	670	-175	1149	-459	-415	-538	-561	-575	-578
Private Investment	Change (%)	0.01	0.00	0.00	0.00	0.01	-0.01	0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02
	Change (2019M$)	28	-4	-9	-16	40	-26	63	-58	-78	-96	-99	-96	-89
Personal Income	Change (%)	0.00	0.00	0.00	0.00	0.01	-0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change (2019M$)	109	-50	-21	-37	201	-158	341	-330	-216	-276	-286	-299	-307
GSP	Change (%)	0.01	0.00	0.00	0.00	0.01	0.00	0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Change (2019M$)	179	-18	5	-12	351	-89	601	-237	-209	-275	-287	-293	-294

Under Alternative 2, there would be less demand for shore power equipment and capture and control units due to the exclusion of auto and ro-ro vessels, and the portion of labor and operational activities attributed to auto carriers and ro-ro vessels would not be needed. Under the Proposed Regulation, demand for shore power equipment, capture and control technology units, and associated labor and operational costs would increase.

d. Cost-Effectiveness

Cost-effectiveness values for the Proposed Regulation and Alternative 2 were calculated using the metrics described in this Chapter and are summarized in Table F17. Based on all metrics, staff estimated that Alternative 2 would be slightly less cost-effective than the Proposed Regulation because it gets fewer emissions reductions.

Table F17: Cost-Effectiveness of the Proposed Regulation and Alternative 2

Metric	Carl Moyer Methodology ($/weighted ton)
Proposed Regulation	$83,159
Alternative 2	$86,640
Difference in Cost-Effectiveness	$3,481

e. Reason for Rejecting

Alternative 2 was rejected because, while it has a lower cost, it also would result in lower emission reductions. The lost emissions reductions under Alternative 2 would have a negative health impact on the communities surrounding the ports due to higher exposure to cancer-causing DPM. Alternative 2 would also provide fewer NOx reductions to aid attainment of the National Ambient Air Quality Standards in the South Coast Air Basin. To reach the target carrying capacity of the Basin for attainment as required by federal law, fewer reductions from vessels at berth means that other sources would need to make up for the reductions foregone by eliminating controls on ro-ro vessels. Those other stationary and mobile sources would need to implement more stringent, and potentially more expensive, controls.

APPENDIX A

Control Measure for Ocean-Going Vessels At Berth

Cost Analysis Inputs and Assumptions for Standardized Regulatory Impact Assessment

8/1/2019

This document was prepared by California Air Resources Board (CARB) Staff to document inputs and assumptions used in the development of cost estimates for the Proposed Control Measure for Ocean-Going Vessels At Berth (Proposed Regulation).

Staff developed 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.

Contents

Table I. Scope and Timing of Analysis

<table>
<tr><td>Years of Cost Analysis</td><td>2020 through 2032</td></tr>
<tr><td>Proposed Regulation Implementation Schedule</td><td>2021 – Container/Reefer and Cruise
2025 – Ro-Ro
2027 – Tankers (Ports of Los Angeles and Long Beach)
2029 – Tankers (all other terminals in the State)</td></tr>
<tr><td>Terminal Thresholds (used to determine applicable terminals and vessel visits)</td><td>
<table>
<tr><th>Vessel Type</th><th>Annual Terminal Threshold (Annual Visits)</th></tr>
<tr><td>Container/Reefer</td><td>20+</td></tr>
<tr><td>Cruise</td><td>20+</td></tr>
<tr><td>Ro-Ro</td><td>20+</td></tr>
<tr><td>Tanker</td><td>20+</td></tr>
</table>
</td></tr>
<tr><td>Standardized Regulatory Impact Assessment (SRIA) Alternatives</td><td><u>Alternative 1</u>: Shore power required for all vessel types (no capture and control).
<u>Alternative 2</u>: Same as Proposed Regulation, except Ro-Ro vessels not subject to emission control requirements.</td></tr>
<tr><td>Staff assumptions regarding control technology</td><td>
<table>
<tr><th>Vessel Type</th><th>Proposed Regulation and Alternative 2</th><th>Alternative 1</th></tr>
<tr><td>Container/Reefer</td><td>Primarily shore power, with some barge-based capture and control</td><td>Shore power only</td></tr>
<tr><td>Cruise</td><td>Shore power only</td><td>Shore power only</td></tr>
<tr><td>Ro-Ro</td><td>Combination of land-based and barge-based capture and control</td><td>Shore power only</td></tr>
<tr><td>Tanker</td><td>Land-based capture and control only</td><td>Shore power only</td></tr>
</table>
</td></tr>
<tr><td>Shore power vessels</td><td>“Frequent vessel” means a vessel that visits any terminal in California 4+ times per year.</td></tr>
<tr><td>Staff assumptions regarding timing of costs</td><td><u>Terminal Infrastructure Costs:</u>

Container/Reefer, Cruise, and Ro-Ro: costs begin ONE YEAR prior to implementation date.
Tankers: costs begin THREE YEARS prior to implementation date.

<u>Vessel Modification Costs:</u>

Container/Reefer, Cruise, and Ro-Ro: costs begin ONE YEAR prior to implementation date.
Tankers: costs begin ONE YEAR prior to implementation date for Alternative 1. No vessel modification costs assumed for Proposed Regulation and Alternative 2.

<u>Maintenance, Labor, and Energy Costs</u>

All costs start in the implementation year for each vessel type.

<u>Administrative Costs:</u></td></tr>
</table>

	• Staff costs are incurred beginning in 2020 – 2021 for CARB personnel-years (PYs) and 2021 for other agency PYs. • Initial port plan and terminal plan costs for all vessel categories are assumed to occur in the 12 MONTHS prior to the deadline in the Proposed Regulation. • Terminal plans updates for Ro-Ro and Tanker vessels are assumed to occur in the 12 MONTHS prior to the due date in the Proposed Regulation. • Vessel visit reports assumed to occur in the calendar year of the vessel visit, based on the due date of 7 days following each vessel visit in the Proposed Regulation. Feasibility, Engineering and Permitting Costs: • Feasibility, engineering and permitting costs for Tanker terminal infrastructure projects are assumed to occur simultaneously over the SEVEN YEARS prior to the implementation date at the terminal. Capture and Control Technology Approvals: • Capture and control technology approvals would occur over the TWO YEAR period prior to Tanker implementation dates and over the ONE YEAR period prior to other vessel category implementation dates. (Note that these costs were quantified for macroeconomic modeling only and are not included in the total costs of the Proposed Regulation)
Terminal and vessel equipment life	• The expected life of terminal equipment is 20 years as described in **Table XII**. Capital Recovery Factor (CRF) (5%, 20 years) = 0.0802. • The expected life of vessel shore power equipment is 10 years as described in **Table XII**. CRF (5%, 10 years) = 0.1295. • After 10 years, Staff assumes annual vessel shore power equipment costs would equal 50 percent of the annualized capital costs to account for major repairs and component replacements.
Direct costs of regulation versus costs incurred by other parties	Direct costs of the regulation that are included in the total annualized costs of the regulation: • All infrastructure costs (terminal and vessel-side), labor, maintenance, and energy costs for shore power and land-based capture and control systems. • Hourly barge-based capture and control system utilization fees. • All administrative costs related to port plans, terminal plans, vessel visit reports, feasibility studies, engineering and permitting costs, and remediation costs. • Administrative costs incurred by the State of California including CARB and other state and local government agencies. Costs incurred by parties outside the regulated industry and impacted agencies and NOT included in the total annualized costs of the regulation (these costs ARE included in the SRIA macroeconomic modeling):

	- Direct costs to barge capture and control technology providers. Staff assumes that these costs would be incurred by the technology providers, who would charge an hourly fee to the barge user. (The hourly fees are included in the total annualized costs to the regulated industry.) - Direct costs to land-based capture and control technology providers. Staff assumes that these costs would be incurred by the technology providers, who would recover the costs through the sale of the systems.
Industry growth factors	Annual industry growth factors (see **Table IX**) are applied uniformly to cost calculations to account for multiple individual factors including the potential for increased vessel visits, vessel sizes, infrastructure requirements due to increased economic activity, labor and energy costs.

Table II. Barge-Based Capture and Control Systems – Cost Inputs

Data Input	**Value**	**Basis**
Cost to obtain initial CARB technology approval	$170,000 per approval	Ruben Garcia (AEG) email to Angela Csondes (CARB) dated 3/27/19 stated cost range of $180,000-$200,000. This includes completing 200 operating hours with 3rd party testing, labor, and tugs. Nick Tonsich (CAEM) email to Angela Csondes (CARB) dated 10/17/18 stated cost estimate of $150,000 or less per future approval.
Number of Barge-Based Technology Approvals	1	Staff estimates approximately 3 companies would each seek a technology approval for Ro-Ro capture and control systems, including land-based and barge-based. Staff apportioned the technology approvals according to the anticipated numbers of barge-based and land-based systems.

Hourly usage fee for Container/Reefer and Ro-Ro vessels	$900/hr average for Container/Reefer and Ro-Ro vessel types	Ruben Garcia (AEG) emails to Angela Csondes (CARB) dated 3/27/19 and 4/3/19. Applies to Container/Reefer and Ro-Ro vessel types.
Hourly usage fee for tanker vessels	N/A	Staff conversations with tanker terminals indicated none are planning to use barge systems at this time.

Table III-A. Land-Based Capture and Control Systems for Ro-Ro Vessels – Cost Inputs

Data Input	Value	Basis
Land-based system capital cost	$3,600,000	Claimed confidential data obtained from industry sources that requested non-attribution.
Labor costs	$0	Tri-Mer stated during 4/16/19 CARB meeting that no additional labor beyond existing crane mechanics is required during control of container vessel emissions. Staff has no information at this time to indicate additional labor would be needed for Ro-Ro vessels.
Annual maintenance costs for emission control system	$17,500 per system	Claimed confidential data obtained from an industry source that requested non-attribution. The source verbally provided Staff an estimated range of $15,000 - $20,000 annually per system, which includes potential repair costs for components including the generator, blower, and filter replacement.
Operating and Other Costs	$100 per hour	Claimed confidential data obtained from an industry source that requested non-attribution. The source verbally stated to Staff that this estimate includes fuel and other consumables required to operate the system.
Annual performance testing cost	$12,000 per system	Claimed confidential data obtained from an industry source that requested non-attribution. The source verbally stated to Staff that $1,000 per month was a reasonable estimate for a staff person to process and report CEMS data.
Cost for initial technology approval (applicable to	$150,000 per system	Claimed confidential data obtained from an industry source that requested non-attribution.

macroeconomic modeling only)		Note: Staff assumes technology approval costs would be incurred by the technology developer and are not summed into the annualized cost to the regulated industry, as described in **Table I**.
Number of Land-Based Technology Approvals for Ro-Ro	2	Staff estimates approximately 3 companies would each seek a technology approval for Ro-Ro capture and control systems, including land-based and barge-based. Staff apportioned the technology approvals according to the anticipated numbers of barge-based and land-based systems.

Table III-B. Land-Based Capture and Control Systems for Tanker Vessels – Cost Inputs

Data Input	**Value**	**Basis**
Land-based emission control system capital cost	$6,517,857 per berth	Average of two values: 1) $3,500,000 for a 14,000 scfm system (claimed confidential data obtained from an industry source that requested non-attribution), scaled up proportionally to a volumetric flow rate of 31,250 scfm (estimated from the mid-range of a 100,000 - 125,000 scfm design target estimated by Chevron during a meeting with CARB on 6/10/19, for their four berths at Richmond Long Wharf; and 2) $5,000,000 per emission control system cited in the Western States Petroleum Association (WSPA) letter to CARB dated May 30, 2019. The WSPA letter contained cost information collected and aggregated by WSPA's consultant, Stantec, from four WSPA members, whose identity were disclosed to CARB by WSPA. CARB held follow-up conference calls with WSPA, Stantec, and the participating WSPA members to understand and corroborate the claimed confidential information summarized in WSPA's letter.
Tanker terminal infrastructure (emission control system connections, electrical, foundation, etc.)	$7,000,000 per berth	WSPA letter to CARB dated May 30, 2019.

Emission control system support structure	POLA/POLB tanker terminals: $5,000,000 per berth All other tanker terminals statewide: $15,000,000 per berth	WSPA letter to CARB dated May 30, 2019. These are the mid-range values of the $0 - $10,000,000 cost range provided in the WSPA letter for POLA/POLB terminals and the $10,000,000 - $20,000,000 cost range provided for Northern California terminals. Staff used the mid-range values to reflect that a support structure would not be needed at all locations, depending on the placement of the emission control system (on land, on a wharf, or over water) and existing infrastructure. WSPA concurred with Staff's use of these mid-range values on a June 12, 2019 phone call.
Piping infrastructure from berth to land-based emission control system	$4,500,000 per berth	Staff analysis of data from AEG Benicia Ro-Ro AMECS project, ShoreKat project, and EU 2001 VOC control system cost estimates. WSPA members concurred with this value in the May 30, 2019 letter to CARB.
Crane cost	$7,000,000 per crane	WSPA letter to CARB dated May 30, 2019.
Number of cranes per berth	POLA/POLB tanker terminals: 1 All other tanker terminals statewide: 2	WSPA letter to CARB dated May 30, 2019. Subsequent Staff conversations held in June 2019 with the participating WSPA members that contributed data to the WSPA letter, and a letter from Chevron to CARB dated May 29, 2019, indicated that the cranes required would be large with a very long reach to exhaust stacks, and two cranes would be needed at northern California terminals to facilitate vessels berthing either starboard or port side. At POLA/POLB, most vessels would berth in a single direction, necessitating only a single crane at most berths.
Crane support structure cost	$10,000,000 per crane	WSPA letter to CARB dated May 30, 2019.
Number of crane support structures per berth	POLA/POLB tanker terminals: 1 All other tanker terminals statewide: 2	WSPA letter to CARB dated May 30, 2019. Subsequent Staff conversations held in June 2019 with three WSPA members that contributed data to the WSPA letter indicated that this cost would be necessary for every crane whether it is constructed on a separate over-water structure (crane dolphin) or on an existing wharf, due to the large size, weight and moment of the crane, and strict seismic standards statewide.
Labor costs	$1,000,000 per berth annually	Based on conversations between Staff, capture and control technology providers, and terminal operators. This includes the CARB-hosted meeting with Tri-Mer and tanker industry

		representatives held on April 16, 2019, calls and meetings between CARB and tanker terminal operators who requested non-attribution and a call between CARB Staff and Tri-Mer held in June 2019. These conversations indicated that the labor needs would vary depending on site characteristics (e.g. number of capture and control units per terminal and distance between berths). Based on these conversations, which included terminal operators' input on fully burdened terminal labor costs, Staff assumes that one additional full time-equivalent at $250,000 per year would be needed at each berth where a capture and control crane is installed, to ensure safe operation of the unit in proximity to hazardous cargo.
Annual maintenance costs	0.3% of capital costs annually	Staff did not receive consistent information from stakeholders regarding an appropriate value to estimate maintenance cost for both the emission control system and the associated infrastructure. Therefore, Staff assumes that maintenance costs would be similar to shore power equipment in proportion to project capital costs, and applied 0.3% based on the average shore power terminal equipment maintenance costs of $24,285 and the container/reefer berth shore power retrofit capital costs of $7,010,813 per berth as indicated by the June 2018 vessel operator surveys.
Operating costs	POLA/POLB tanker terminals: $200 per hour All other tanker terminals statewide: $500 per hour	Claimed confidential data obtained from an industry source that requested non-attribution indicated $100 per hour. The source verbally stated to Staff that this estimate includes fuel and other consumables required to operate the system. Staff understands that this cost does not include potential additional energy costs to transport exhaust at tanker terminals where the capture and control unit is located a distance from the berth, therefore has scaled up costs to account for this factor. Staff did not receive any data from industry on which to base a scale-up factor, therefore assumes that costs would double from $100 to $200 per hour at POLA/POLB berths and would further increase to $500 at Northern California terminals, many of which are located offshore.
Annual performance testing cost	$12,000 per system	Claimed confidential data obtained from an industry source that requested non-attribution.

		The source verbally stated to Staff that $1,000 per month was a reasonable estimate for a staff person to process and report CEMS data.
Tanker Vessel Boiler Modifications	$0	Claimed confidential data obtained from an industry source that requested non-attribution. The source verbally stated to Staff that the system is designed not to require vessel modifications because it uses negative pressure to extract exhaust, which does not create back pressure. Therefore, for a land-side system, Staff assumes no vessel modifications would be required.
Cost for initial technology approval (applicable to macroeconomic modeling only)	$150,000 per system	Claimed confidential data obtained from an industry source that requested non-attribution. Note: Staff assumes technology approval costs would be incurred by the technology developer and are not summed into the annualized cost to the regulated industry, as described in **Table I**.
Number of Land-Based Technology Approvals	POLA/POLB tanker terminals: 3 All other tanker terminals statewide: 4	Staff anticipates receiving an estimated 7 applications for technology approvals for land-based systems at tanker terminals. Staff's Berth Analysis estimates approximately 23 land-based capture and control systems would be built, 10 in POLA/POLB and 13 elsewhere in the state. Staff apportioned the total number of 7 estimated technology approvals by the number of systems estimated for each location.

Table IV. Tanker Terminal Infrastructure Feasibility, Engineering and Permitting Costs

Data Input	Value	Basis
Feasibility study cost	$500,000 per berth	Tri-Mer stated an estimate of $500,000 - $1,000,000 per feasibility study during 4/16/19 CARB meeting. Staff divided the average of this range, $750,000, by approximately 1.5 berths per tanker terminal covered under the Proposed Regulation statewide = $500,000 per berth.
Engineering costs	12 percent of total project costs (capital costs, which are	Chevron stated in a meeting with CARB on June 10, 2019 that an appropriate "rule of thumb" for estimating engineering costs would

	assumed to include installation and construction costs)	be 10 percent of the total installed project cost. Marathon stated in a conference call on June 6, 2019 that a rough estimate for engineering costs would be 13 to 14 percent of total project costs. Staff took the average of these two estimates to yield a factor of 12 percent of total capital costs (including installation and construction).
Permitting costs	4 percent of total project costs (capital costs, which are assumed to include installation and construction costs)	Oil terminal operators stated in a meeting and two conference calls in June 2019 the following: An appropriate “rule of thumb” for estimating permitting costs would be 10 percent of the engineering costs, or 1 percent of the total installed project cost. They acknowledged that the actual permitting costs would vary widely depending on factors such as whether a full Environmental Impact Report (EIR) is required, mitigation requirements, and applicable local agency fees. A rough estimate for permitting costs would be 6 to 7 percent of the total project costs. Permitting costs may be roughly $2,000,000 to $3,000,000 per project. Staff calculated this would be equivalent to 4.6 percent of total project costs based on the average per-berth totals that WSPA provided in their May 30, 2019 letter and the statewide average of approximately 1.5 berths per tanker terminal. Staff used an average of these three estimates to yield a factor of 4% of total capital costs (including installation and construction).

Table V. Auxiliary Engine Effective Power Values

<table>
<tr><th>Data Input</th><th colspan="2">Value</th><th>Basis</th></tr>
<tr><td rowspan="5">Auxiliary engine effective power values for each vessel type.

Note: These values are used to calculate shore power energy costs and cost savings only</td><td>Vessel Type</td><td>kilowatts (kW)</td><td rowspan="5">Staff calculated average effective power per vessel type using the same power values cited in Table 7 of the emission inventory methodology https://ww3.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf. Values used in cost analysis for container/reefer and tanker vessels are calculated as one kW-average per vessel type, weighted by average vessel kW at each port/terminal and vessel visits to each port/terminal.</td></tr>
<tr><td>Container/Reefer</td><td>1,053</td></tr>
<tr><td>Cruise</td><td>5,620</td></tr>
<tr><td>Ro-Ro</td><td>1,159</td></tr>
<tr><td>Tankers (all)</td><td>944</td></tr>
</table>

Table VI. Duration of Emission Control at Berth

<table>
<tr><th>Data Input</th><th colspan="2">Value</th><th>Basis</th></tr>
<tr><td rowspan="5">Average duration of emission control at berth per vessel visit (hours) for each vessel type</td><td>Vessel Type</td><td>hours</td><td rowspan="5">Staff calculated average duration of emission control at berth using the same time at berth and stay time values used for the emission inventory and calculated weighted average by location and vessel visits for each vessel type.</td></tr>
<tr><td>Container/Reefer</td><td>38.8</td></tr>
<tr><td>Cruise</td><td>11.2</td></tr>
<tr><td>Ro-Ro</td><td>19.8</td></tr>
<tr><td>Tankers (all)</td><td>40.7</td></tr>
</table>

Table VII. Administrative Cost Inputs

Data Input	Value			Basis
Number of port plans	Vessel Type	Number of Plans	Year(s) Costs Incurred	1 per port, based on number of ports with terminals that exceed the threshold in **Table I**. Timing of costs described in **Table I.**
	Container/Reefer	5	2020-2021	
	Cruise	4	2020-2021	
	Ro-Ro	5	2020-2021	
	Tankers (applies to So. CA Only)	2	2020-2021	
	Total:	16	--	
Number of initial terminal plans and number of terminal plans included in each port plan	Vessel Type	Number of Plans	Year(s) Costs Incurred	1 per terminal, based on the number of terminals over the terminal threshold in **Table I.** Timing of costs described in **Table I.** Where deadlines occur mid-year, costs are split over two calendar years.
	Container/Reefer	19	2020-2021	
	Cruise	5	2020-2021	
	Ro-Ro	11	2020-2021	
	Tankers – So. CA	8	2020-2021	
	Tankers – all other terminals	12	2020-2021	
	Total:	55	--	
Number of terminal plans to be revised and resubmitted	Vessel Type	Number of Plans	Year(s) Costs Incurred	Applies to all terminal plans for Ro-Ro and Tanker terminals
	Ro-Ro	11	2020-2021	
	Tankers – So. CA	8	2020-2021	
	Tankers – all other terminals	12	2020-2021	
	Total:	31	--	
Annual number of terminal reports	Vessel Type	Number of Reports	Year(s) Costs Incurred	1 terminal report per vessel visit, based on the number of vessel visits to California terminals that would be regulated under the Proposed Regulation. These values are equivalent to "All annual vessel visits" in **Tables XIII-A through XIII-E.**
	Container/Reefer	3,742	Annually 2021 - 2032	
	Cruise	527	Annually 2021 - 2032	
	Ro-Ro	1,017	Annually 2025 - 2032	
	Tankers – So. CA	610	Annually 2027 - 2032	
	Tankers – all other terminals	1,005	Annually 2029 - 2032	

<table>
<tr><td></td><td><table>
<tr><td>Bulk/ General</td><td>1,043</td><td>Annually 2029 - 2032</td></tr>
<tr><td>Total:</td><td>7,944</td><td></td></tr>
</table></td><td></td></tr>
<tr><td>Annual number of vessel reports</td><td><table>
<tr><th>Vessel Type</th><th>Number of Reports</th><th>Year(s) Costs Incurred</th></tr>
<tr><td>Container/Reefer</td><td>3,742</td><td>Annually 2021 - 2032</td></tr>
<tr><td>Cruise</td><td>527</td><td>Annually 2021 - 2032</td></tr>
<tr><td>Ro-Ro</td><td>1,017</td><td>Annually 2025 - 2032</td></tr>
<tr><td>Tankers – So. CA</td><td>610</td><td>Annually 2027 - 2032</td></tr>
<tr><td>Tankers – all other terminals</td><td>1,005</td><td>Annually 2029 - 2032</td></tr>
<tr><td>Bulk/ General</td><td>1,043</td><td>Annually 2029 - 2032</td></tr>
<tr><td>Total:</td><td>7,944</td><td></td></tr>
</table></td><td>1 vessel report per vessel visit, based on the number of vessel visits to California terminals that would be regulated under the Proposed Regulation. These values are equivalent to “All annual vessel visits” in **Tables XIII-A through XIII-E.**</td></tr>
<tr><td>Cost per port plan</td><td>$10,000 per regulated terminal</td><td>Staff estimate. Assumes 100 employee-hours at $100/hour</td></tr>
<tr><td>Cost per terminal plan</td><td>$2,500 per regulated berth</td><td>Staff estimate. Assumes 25 employee-hours at $100/hour</td></tr>
<tr><td>Cost per terminal report</td><td>$100 per vessel visit</td><td>Visit information would be submitted through CARB’s electronic Freight Regulations Reporting System (FRRS), which is currently under development. Staff assumes 1 employee-hour at $100/hour.</td></tr>
<tr><td>Cost per vessel report</td><td>$100 per vessel visit</td><td>Visit information would be submitted through FRRS. Staff assumes 1 employee-hour at $100/hour.</td></tr>
<tr><td>CARB PYs</td><td>2 Air Pollution Specialists (APS) Range C – Transportation and Toxics Division (TTD), $180,000 Year 1, $179,000 subsequent years. The first PY begins in 2020, the second begins in 2021.

2 Air Pollution Specialists (APS) Range C – Enforcement, $180,000 Year 1, $179,000 subsequent years. The first PY begins in 2021, the second begins in 2027.

1 Air Resources Technician (ART) – TTD,</td><td>PY cost sheet provided by CARB’s Office of Economic Policy & Analysis (OEPA).</td></tr>
</table>

	$88,000 Year 1, $87,000 subsequent years. PY begins in 2020. 1 Air Resources Technician (ART) – Enforcement, $88,000 Year 1, $87,000 subsequent years. PY begins in 2021. 1 Air Resources Engineer (ARE) Range D –TTD $189,000 Year 1, $188,000 subsequent years. PY begins in 2020.	
Other State agency PYs	2 for California State Lands Commission (CSLC) beginning in 2021 1 combined for all other State Agencies beginning in 2021 Each PY cost assumed equivalent to CARB ARE Range D	Staff understands through conversations with CSLC including a phone call held on March 27, 2019 and tanker terminal operators that a number of state, local and federal agencies would potentially be involved in permitting and approval of infrastructure projects. The agencies involved and the scope of their reviews would be highly dependent on project-specific details that would vary for each terminal infrastructure project. Staff therefore made assumptions on additional PYs that would be required based on its understanding of work required to conduct project reviews.
Local agency PYs	1 combined for all local agencies beginning in 2021 Each PY cost assumed equivalent to CARB ARE Range D	
Federal agency PYs	1 combined for all federal agencies beginning in 2021 Each PY cost assumed equivalent to CARB ARE Range D	

Table VIII. Electricity and Fuel Cost Inputs

Data Input	Value	Basis
Future electricity rates for all analysis years	$0.18 per kilowatt-hour (kWh) through 2030 $0.19 per kWh in 2031 and 2032 $1.16 per kWh for all analysis years for Port of San Diego cruise vessels only	California Energy Commission Mid Case Revised Demand Forecast (CEC, updated February 21, 2018). Projected rates for PG&E, LADWP, SDG&E, and SCE averaged to produce an average statewide rate. This statewide rate is used for all ports/terminals and vessel types, with the exception of cruise vessels at Port of San Diego. Port of San Diego provided Staff with the "Prepared Direct Testimony of Cynthia Fang on Behalf of San Diego Gas & Electric Company, Chapter 4, Before the Public Utilities Commission of the State of California, September 13, 2017, page CF-10." This information references an open regulatory case before the California Public Utilities Commission (CPUC). The CPUC has approved a rate change that would result in shore power electricity rates of approximately $1.16 per hour; the Port has requested rate relief to lower the rate, which is pending review by CPUC, and at this time it is still unknown whether any rate relief will be granted. Port staff stated the new rates would disproportionately impact the effective shore power electricity rate for cruise vessels relative to other vessel types at the Port because cruise vessels do not call during Mid-May through September, when the demand charges would apply. Based on this information, Staff applied the currently approved equivalent rate of $1.16 per kWh for Cruise vessels at the Port of San Diego to the cost analysis, because it is substantially different than the statewide average. Port of Oakland noted in their June 10, 2019 letter to CARB that the Port bills shore power usage based on hours of use, not kWh drawn, at all but one of their terminals. The shore power usage fee posted on the Port of Oakland's website https://www.oaklandseaport.com/development-programs/shore-power/ (accessed June 19, 2019) is $298 per hour (usage rate of $267 plus maintenance fee of $31 per hour). In the same letter, the Port noted that the statewide average Container/Reefer emission control duration of 38.8 hours per vessel visit used in the cost analysis is about twice the average time for shore power duration at Port of Oakland. Staff estimates the default electricity rate of $0.18 - $0.19 per kWh applied to the average auxiliary engine effective

		power value of 1,053 kW and average emission control duration of 38.8 hours for Container/Reefer vessels is similar to applying the Port’s hourly rate to an emission control duration of approximately half the average. Therefore, Staff assumes the statewide CEC forecast referenced above is an appropriate approximation for all ports in the cost analysis, with the exception of Cruise vessels at Port of San Diego as noted above.
Marine fuel prices for all analysis years	$1,193 per metric ton (MT) in 2021, increasing annually to $1,753/MT in 2032	Based on marine gas oil (MGO) price of $763.50/MT for ports of Los Angeles and Long Beach accessed from http://www.shipandbunker.com/prices on 4/26/19, adjusted using U.S. Energy Information Administration (EIA) price projections for transportation diesel fuel. https://www.eia.gov/outlooks/aeo/data/browser/#/?id=12-AEO2018&cases=ref2018&sourcekey=0
Brake-specific fuel consumption for calculating fuel savings	217 grams/kWh	CARB emission inventory methodology document Appendix A, fuel consumption factor for auxiliary engines at berth, distillate fuel. https://ww3.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf
Low Carbon Fuel Standard (LCFS) credit value	$0.10 – 0.11/kWh	Based on LCFS Staff analysis dated 4/12/19.
Percent of potential LCFS credits anticipated to be claimed	100%	Staff assumes that entities eligible to claim LCFS credits would maximize their opportunity for revenue from these credits.
Who benefits from LCFS credits claimed	Container/Reefer: Ports All other vessel types: Terminal	Based on the LCFS Regulation Sections 95483 (c)(5)(A) and (B) designating the owner of the fueling supply equipment (FSE) as the credit generator unless they agree by a written contract to designate another entity to generate the credits. CARB determined the Port of Oakland is the FSE owner for generating LCFS credits. Since all of the additional Container/Reefer visits accounted for in this cost analysis occur at Port of Oakland, Staff assumes that the Port would incur the benefit of LCFS credits for Container/Reefer vessels. In other cases, the terminal would be the FSE, and Staff assumes that the terminal would benefit from LCFS credits for all other vessel types.

Table IX. Growth Factors

Data Input	**Value**					**Basis**
	Year	Container/Reefer	Cruise	Ro-Ro	Tanker	
Annual industry growth factors	2019	8.0%	7.5%	7.5%	1.0%	Annual values compounded through analysis period, year 2017 base, specific to vessel type. Weighted average of values used for emissions inventory. https://ww3.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf These values are applied to all cost calculations as describe in **Table I**.
	2020	15.3%	16.0%	11.5%	1.5%	
	2021	19.4%	20.2%	15.1%	2.7%	
	2022	23.8%	24.7%	18.4%	3.5%	
	2023	28.5%	29.2%	21.9%	4.3%	
	2024	33.4%	34.0%	25.4%	5.1%	
	2025	41.0%	38.9%	29.1%	5.9%	
	2026	44.4%	44.0%	32.9%	7.1%	
	2027	48.2%	49.3%	35.9%	8.2%	
	2028	52.3%	54.8%	39.0%	9.4%	
	2029	56.7%	60.5%	42.2%	10.5%	
	2030	61.4%	66.5%	45.4%	11.7%	
	2031	69.1%	72.6%	48.9%	13.0%	
	2032	77.2%	78.9%	52.3%	14.3%	

Table X. Cost Apportionment to Ports and Terminals

<table>
<tr><th>Data Input</th><th colspan="3">Value</th><th>Basis</th></tr>
<tr><td colspan="5">Note: Cost apportionment factors are used to assign costs to either ports or terminals for the purpose of the SRIA macroeconomic modeling analysis. These factors do not impact the total calculated costs to the regulated industry.</td></tr>
<tr><td rowspan="3">Apportionment of shore power infrastructure capital costs to ports vs. terminals</td><td>Scenario</td><td>% borne by port</td><td>% borne by terminal</td><td rowspan="3">Staff assumes all ports and marine terminals would incur capital costs, as applicable. POLB terminal operators indicated in discussions with Staff that infrastructure capital costs would be incurred by the Port initially prior to potentially being passed onto the terminal operators through lease agreements. On this basis, Staff assumes that the Port would bear the initial cost and disclose that it may be passed along through leases.</td></tr>
<tr><td>Proposed Regulation and Alternative 2</td><td>100% for all ports</td><td>0% for all terminals at ports</td></tr>
<tr><td>Alternative 1</td><td>100% for all ports</td><td>0% for terminals at ports;
100% for all marine terminals</td></tr>
<tr><td rowspan="3">Apportionment of shore power terminal equipment maintenance costs to ports vs. terminals</td><td>Scenario</td><td>% borne by port</td><td>% borne by terminal</td><td rowspan="3">Staff assumptions based on discussions with POLB and POLA terminal operators.</td></tr>
<tr><td>Proposed Regulation and Alternative 2</td><td>100% for all ports except POLB;
0% for POLB</td><td>0% for all terminals at ports except POLB;
100 % for terminals at POLB</td></tr>
<tr><td>Alternative 1</td><td>100% for all ports except POLB;
0% for POLB</td><td>0% for all terminals at ports except POLB;
100 % for terminals at POLB;
100% for all marine terminals</td></tr>
</table>

<table>
<tr>
<td>Apportionment of shore power terminal labor costs to ports vs. terminals</td>
<td>
<table>
<tr><th>Scenario</th><th>% borne by port</th><th>% borne by terminal</th></tr>
<tr><td>Proposed Regulation and Alternative 2</td><td>100% for POLA;
0% for all other ports</td><td>100% for terminals at all ports except POLA; 0% for terminals at POLA</td></tr>
<tr><td>Alternative 1</td><td>100% for POLA;
0% for all other ports</td><td>100% for terminals at all ports except POLA; 0% for terminals at POLA;
100% for all marine terminals</td></tr>
</table>
</td>
<td>Staff assumptions based on discussions with POLB and POLA terminal operators.</td>
</tr>
<tr>
<td>Apportionment of land-based capture and control infrastructure capital costs to ports vs. terminals (Tankers)</td>
<td>
<table>
<tr><th>Scenario</th><th>% borne by port</th><th>% borne by terminal</th></tr>
<tr><td>Proposed Regulation and Alternative 2</td><td>100% for all ports</td><td>0% for all terminals at ports;
100% for all marine terminals</td></tr>
</table>
</td>
<td>Staff assumes all ports and marine terminals would incur capital costs, as applicable. POLB terminal operators indicated in discussions with Staff that infrastructure capital costs would be incurred by the Port initially prior to potentially being passed onto the terminal operators through lease agreements. On this basis, Staff assumes that the Port would bear the initial cost and disclose that it may be passed along through leases.</td>
</tr>
</table>

<table>
<tr>
<td>Apportionment of land-based capture and control system costs to ports vs. terminals (Tankers and Ro-Ros)</td>
<td><table><tr><th>Scenario</th><th>% borne by port</th><th>% borne by terminal</th></tr><tr><td>Proposed Regulation and Alternative 2</td><td>100% for Port of Hueneme;
0% for all other ports</td><td>100% for all terminals at ports except Port of Hueneme;
100% for all marine terminals</td></tr></table></td>
<td>Staff assumes all terminals would incur land-based capture and control device costs except for terminals at the Port of Hueneme and the Port of San Diego, which are operating ports (no terminal operators). Terminal operators indicated in discussions with Staff that capture and control device costs would be incurred by the terminals.

Note: Ro-Ro vessels are excluded from Alternative 2.</td>
</tr>
<tr>
<td>Apportionment of land-based capture and control equipment maintenance costs</td>
<td><table><tr><th>Scenario</th><th>% borne by port</th><th>% borne by terminal</th></tr><tr><td>Proposed Regulation and Alternative 2</td><td>100% for all ports except Port of Long Beach;
0% for Port of Long Beach</td><td>100% for terminals at Port of Long Beach;
0% for all other terminals</td></tr></table></td>
<td>Staff assumes that all ports would incur land-based capture and control maintenance costs except for the Port of Long Beach.</td>
</tr>
<tr>
<td>Apportionment of land-based capture and control equipment labor costs</td>
<td><table><tr><th>Scenario</th><th>% borne by port</th><th>% borne by terminal</th></tr><tr><td>Proposed Regulation and Alternative 2</td><td>0% for all Ports except Port of Los Angeles;
100% for Port of Los Angeles</td><td>100% for all terminals at ports except Port of Los Angeles;
0% for terminals at Port of Los Angeles</td></tr></table></td>
<td>Staff assumes that all terminals would incur land-based capture and control labor costs except for terminals at the Port of Los Angeles.</td>
</tr>
<tr>
<td>Who bears the cost for terminal cable reels</td>
<td>Terminals</td>
<td>Staff assumption based on discussions with POLB terminal operators.

Note: Staff Berth Analysis indicated no terminal cable reels would be purchased.</td>
</tr>
</table>

Apportionment of CARB and other agency personnel costs by vessel type	Vessel Type	CARB Personnel-Year (PY) Apportionment	Other Agency PY Apportionment	Staff assumed that CARB PY costs would be apportioned by the number of terminals for each vessel type, and that other agency PY costs would be apportioned by the number of infrastructure projects required for each vessel type. The values reflect apportionment for the Proposed Regulation scenario, but the same percentages were applied to the Alternatives to estimate costs attributed to each vessel type.
	Container/Reefer	49%	14%	
	Cruise	9%	3%	
	Ro-Ro	17%	0%	
	Tankers – POLA/POLB	11%	36%	
	Tankers – Other Statewide	14%	47%	

Table XI. Berth and Terminal Counts, Anticipated Infrastructure Needs, and Unique Vessels

Data Input	**Value**					**Basis**
Number of terminals subject to terminal threshold, for each vessel type, by port/terminal	Port/Marine Terminal	Container/ Reefer	Cruise	Ro-Ro	Tankers	Based on Staff Berth Analysis, based on terminal threshold in **Table I**. The number of terminals is used to calculate the administrative costs of preparing and submitting Terminal Plans. The number of terminals does not directly impact infrastructure cost calculations because infrastructure costs are calculated on a per-berth basis.
	Los Angeles	7	1	1	5	
	Long Beach	6	1	3	3	
	Oakland	4	--	--	--	
	San Francisco*	--	1	1	--	
	San Diego	1	2	1	--	
	Hueneme	1	--	3	--	
	Stockton Area	--	--	--	1	
	Richmond Area	--	--	1	4	
	Carquinez Area	--	--	1	5	
	Rodeo Area	--	--	--	2	
	Total:	19	5	11	20	

<table>
<tr>
<td>Number of berths subject to terminal threshold, for each vessel type, by port/terminal</td>
<td>
<table>
<tr><th>Port/Marine Terminal</th><th>Container/ Reefer</th><th>Cruise</th><th>Ro-Ro</th><th>Tankers</th></tr>
<tr><td>Los Angeles</td><td>22</td><td>2</td><td>4</td><td>6</td></tr>
<tr><td>Long Beach</td><td>20</td><td>1</td><td>4</td><td>7</td></tr>
<tr><td>Oakland</td><td>12</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>San Francisco</td><td>--</td><td>2</td><td>1</td><td>--</td></tr>
<tr><td>San Diego</td><td>3</td><td>6</td><td>5</td><td>--</td></tr>
<tr><td>Hueneme</td><td>3</td><td>--</td><td>4</td><td>--</td></tr>
<tr><td>Stockton Area</td><td>--</td><td>--</td><td>--</td><td>1</td></tr>
<tr><td>Richmond Area</td><td>--</td><td>--</td><td>1</td><td>7</td></tr>
<tr><td>Carquinez Area</td><td>--</td><td>--</td><td>2</td><td>6</td></tr>
<tr><td>Rodeo Area</td><td>--</td><td>--</td><td>--</td><td>3</td></tr>
<tr><td>Total:</td><td>60</td><td>11</td><td>21</td><td>30</td></tr>
</table>
</td>
<td>Based on Staff Berth Analysis. The berth numbers are the basis of infrastructure calculations, which are estimated on a per-berth basis.</td>
</tr>
<tr>
<td>Number of berth shore power retrofits or land-side capture and control infrastructure projects that Staff anticipates would be constructed in response to the Proposed Regulation or alternatives, for each vessel type, by port/terminal.

For shore power projects, “retrofit” refers to installing shore power at a berth where no shore power currently exists.</td>
<td>
<table>
<tr><th>Port/Marine Terminal</th><th>Container/ Reefer</th><th>Cruise</th><th>Ro-Ro</th><th>Tankers</th></tr>
<tr><td>Los Angeles</td><td>0</td><td>0</td><td>4</td><td>6</td></tr>
<tr><td>Long Beach</td><td>0</td><td>0</td><td>4</td><td>7</td></tr>
<tr><td>Oakland</td><td>0</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>San Francisco</td><td>--</td><td>1</td><td>1</td><td>--</td></tr>
<tr><td>San Diego</td><td>0</td><td>0</td><td>5</td><td>--</td></tr>
<tr><td>Hueneme</td><td>0</td><td>--</td><td>4</td><td>--</td></tr>
<tr><td>Stockton Area</td><td>--</td><td>--</td><td>--</td><td>1</td></tr>
<tr><td>Richmond Area</td><td>--</td><td>--</td><td>1</td><td>7</td></tr>
<tr><td>Carquinez Area</td><td>--</td><td>--</td><td>2</td><td>6</td></tr>
<tr><td>Rodeo Area</td><td>--</td><td>--</td><td>--</td><td>3</td></tr>
<tr><td>Total:</td><td>0</td><td>1</td><td>21</td><td>30</td></tr>
</table>
</td>
<td>Based on Staff Berth Analysis

For Ro-Ro terminals, the number of retrofit projects is only applicable to Alternative 1 (all shore power). Based on the Berth Analysis, Staff does not anticipate that terminal infrastructure projects would be needed to support land-side capture and control systems at Ro-Ro terminals.

For Tanker terminals, the number of land-side capture and control infrastructure projects (Proposed Regulation) or shore power retrofits (Alternative 1) is equivalent to the number of berths subject to the terminal threshold.</td>
</tr>
</table>

<table>
<tr>
<td>Number of new shore power vaults Staff estimates would be installed in response to the Proposed Regulation or alternatives. This refers to adding additional vaults to berths where shore power already exists.</td>
<td><table>
<tr><th>Port/Marine Terminal</th><th>Container/ Reefer</th><th>Cruise</th><th>Ro-Ro</th><th>Tankers</th></tr>
<tr><td>POLA</td><td>2</td><td>0</td><td>--</td><td>--</td></tr>
<tr><td>POLB</td><td>0</td><td>0</td><td>--</td><td>--</td></tr>
<tr><td>Oakland</td><td>3</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>POSF</td><td>--</td><td>0</td><td>--</td><td>--</td></tr>
<tr><td>POSD</td><td>0</td><td>0</td><td>--</td><td>--</td></tr>
<tr><td>Hueneme</td><td>0</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>Total:</td><td>5</td><td>0</td><td>--</td><td>--</td></tr>
</table></td>
<td>Staff Berth Analysis, based on conversations with terminal operators.

Note: Does not apply to marine terminals because none are currently shore power-equipped.</td>
</tr>
<tr>
<td>Number of land-based capture and control systems, for each vessel type</td>
<td>Ro-Ro: 3 total systems

For Tankers, equivalent to the number of berths subject to the terminal threshold (30)</td>
<td>Staff Berth Analysis evaluated the number of land-side systems anticipated to be installed. The estimated cost per land-side capture and control system is directly applied to this value for Ro-Ro vessels. For Tanker vessels, for cost analysis purposes, Staff applied an equivalent cost per berth to all berths (30), rather than basing costs on the total estimated number of individual emission control systems calculated in the Berth Analysis (23).</td>
</tr>
<tr>
<td>Number of terminal infrastructure projects for land-based capture and control</td>
<td>No infrastructure projects assumed for Ro-Ro

For Tankers, equivalent to the number of berths subject to the terminal threshold (30)</td>
<td>Staff assumes that all Tanker terminals would require an infrastructure project to support land-side capture and control. Again, for cost analysis purposes, Staff applied an equivalent cost per berth to all berths.</td>
</tr>
<tr>
<td>Number of barge-based capture and control systems for each vessel type</td>
<td>Container/Reefer: 1 at POLA/POLB

Ro-Ro: 6 (one each at all ports and marine terminals except Hueneme)</td>
<td>Staff Berth Analysis, based on conversations with terminal operators.</td>
</tr>
<tr>
<td>Unique vessel counts for vessel shore</td>
<td><table>
<tr><th>Vessel Type</th><th>Proposed Regulation & Alternative 2</th><th>Alternative 1</th></tr>
</table></td>
<td>PROPOSED REGULATION & ALTERNATIVE 2:
Container/Reefer vessel assumptions:</td>
</tr>
</table>

<table>
<tr>
<td>power equipment retrofits</td>
<td>
<table>
<tr><td>Container/Reefer</td><td>57</td><td>62</td></tr>
<tr><td>Cruise</td><td>26</td><td>26</td></tr>
<tr><td>Auto/Ro-Ro</td><td>0</td><td>261</td></tr>
<tr><td>Tankers - Retrofit</td><td>0</td><td>414</td></tr>
<tr><td>Total:</td><td>83</td><td>763</td></tr>
</table>
</td>
<td>• "Frequent" (defined in **Table I**) non-shore power vessels would install shore power due to the existing regulation (costs not included in this analysis).
• "Infrequent" non-shore power vessels would install shore power due to the new regulation if they visited Oakland 1+ time or POLA/POLB 3+ times in 2017 (costs are included in analysis).
• "Infrequent" non-shore power vessels that do not meet the above criteria would use capture and control Vessel Incident Events (VIEs) or Terminal Incident Events (TIEs).
Cruise vessel assumptions:
• All vessels that visited CA 1+ times in 2017 that do not currently have shore power would install it for the new regulation (costs are included in analysis).
Staff assumes Ro-Ro and Tanker vessels would use capture and control systems instead of shore power.

ALTERNATIVE 1:
Container/Reefer vessel assumptions:
• Same as Proposed Regulation and Alternative 2 except vessels that visited POLA/POLB 2 times in 2017 would also install shore power.
Cruise vessel assumptions:
• Same as Proposed Regulation and Alternative 2.
Auto/Ro-Ro and Tanker vessel assumptions:</td>
</tr>
</table>

		- All vessels that visited CA in 2017 would install shore power. Basis: the number of vessels that make only 1 annual visit is higher than the number of visits that could be covered by TIEs/VIEs.
Number of terminal cable reels	0	Staff Berth Analysis, based on conversations with terminal operators.

Table XII. Shore Power Infrastructure, Maintenance and Labor – Cost Inputs

Data Input	Value	Basis
Shore power berth retrofit cost per Container/Reefer berth	$7,010,813 per berth	$6,316,048 per berth converted from 2012$ to 2019$. This is the cost to install shore power at a berth that does not already have shore power. Average of June 2018 survey values ranging from $3,200,000 to $11,750,000 total cost per berth (assumed to be in 2012$). Includes costs to bring additional power to the terminal where survey respondents indicated it would be needed and provided cost estimates.
Shore power berth retrofit cost per Cruise berth	$83,200,000 per berth (site-specific estimate for Port of San Francisco only)	Estimate provided to staff by the Port of San Francisco in an email to Nicole Light of CARB dated 5/1/19 and discussed on a 5/6/19 phone call. Staff Berth Analysis indicates only the Port of San Francisco would potentially need to retrofit a Cruise berth for shore power.
Shore power vault Installation	$1,993,255 per vault	$1,795,725 per vault converted from 2012$ to 2019$. This is the cost to install an additional shore power vault at a berth that already has shore power. Average of June 2018 survey values ranging from $800,000 to $3,133,333 total cost per vault (assumed to be in 2012$).
Shore power berth retrofit cost per Tanker berth Applies only to Alternative 1	$31,983,333 per berth	Sum of two values: 1) Average of June 2018 survey values ranging from $2,250,000 to $40,000,000 per berth; and 2) The mid-range costs of an Emission Control System Support Structure provided in WSPA's letter to CARB dated May 30, 2019, averaged for POLA/POLB and all other terminals statewide ($10,000,000).

Shore power retrofit cost per Container/Reefer vessel	$878,541 per vessel	$791,478 per vessel converted from 2012$ to 2019$. Average of June 2018 survey values ranging from $268,500 to $2,146,500 per vessel (assumed to be in 2012$). Includes shore power on second side of the vessel where indicated by survey respondents and included in total costs.
Shore power retrofit cost per Cruise Vessel	$1,629,682 per vessel	$1,468,182 per vessel converted from 2012$ to 2019$. Average of June 2018 survey values ranging from $1,000,000 to $2,200,000 per vessel (assumed to be in 2012$). Includes shore power on second side of the vessel where indicated by survey respondents and included in total costs.
Shore power retrofit cost per Ro-Ro Vessel Applies only to Alternative 1	$3,163,500 per vessel	$2,850,000 per vessel converted from 2012$ to 2019$. Average of June 2018 survey values ranging from $900,000 to $4,800,000 per vessel. Includes shore power on second side of the vessel where indicated by survey respondents and included in total costs.
Shore power retrofit cost per Tanker Vessel Applies only to Alternative 1	$2,504,469 per vessel	$2,256,278 per vessel converted from 2012$ to 2019$. Average of June 2018 survey values ranging from $1,612,556 to $2,900,000 per vessel. Includes shore power on second side of the vessel where indicated by survey respondents and included in total costs.
Berth equipment life	20 years	Claimed confidential data obtained from two industry sources that requested non-attribution. The sources indicated equipment life ranging from 15 to 20 years, assuming proper maintenance.
Vessel equipment life	10 years	Claimed confidential data obtained from three industry sources that requested non-attribution. The sources indicated equipment life ranging from 8 years to the life of the ship, assuming proper maintenance.
Terminal cable reel capital cost	$250,000 per reel	Based on Staff conversations with terminal staff where this equipment has been purchased or cost estimates obtained.
Shore Power connection labor cost – non-Tanker vessel visits	$2,355 per visit	Average of June 2018 survey values ranging from $815 to $5,250 per visit.

Shore Power terminal equipment maintenance cost – Container/Reefer	$24,285 annually per berth retrofit	Average of 2018 survey values ranging from $4,000 to $44,571 annually. Conversations with terminal operators at POLB indicated an average cost around $20,000/year.
Shore Power terminal equipment maintenance cost – Cruise	$50,000 annually per berth retrofit	Letter from Port of San Francisco to CARB dated May 29, 2019 provided an estimate of $40,000 at one terminal and $60,000 at the other. Staff used the average of these two values to approximate maintenance costs.
Shore Power vessel equipment maintenance cost	$10,000 annually per vessel retrofit	Averaged from June 2018 survey values ranging from $5,000 to $20,000 annually per vessel.

Table XIII-A. Annual Vessel Visits – Container/Reefer

<table>
<tr><th>Data Input</th><th>Value</th><th>Basis</th></tr>
<tr><td rowspan="2">Annual vessel visits without exceptions, TIEs/VIEs or remediation fund provisions.</td><td><table>
<tr><td>Port</td><td>All annual vessel visits</td></tr>
<tr><td>Los Angeles</td><td>1029</td></tr>
<tr><td>Long Beach</td><td>909</td></tr>
<tr><td>Oakland</td><td>1597</td></tr>
<tr><td>San Diego</td><td>52</td></tr>
<tr><td>Hueneme</td><td>155</td></tr>
<tr><td>Total:</td><td>3,742</td></tr>
</table></td><td>Includes all vessel visits that would be controlled under the Proposed Regulation or alternatives, based on 2017 CSLC data. These visits are equal to all vessel visits in California based off of 2017 data.

This is the base number of vessel visits used for each year of the cost analysis. To account for the potential of increased vessel visits over the analysis period, Staff applied annual industry growth factors as described in Table I.

These vessel visit counts are used to calculate administrative costs of preparing and submitting vessel visit reports.</td></tr>
<tr><td><table>
<tr><td>Port</td><td>Newly regulated vessel visits</td></tr>
<tr><td>Los Angeles</td><td>123</td></tr>
<tr><td>Long Beach</td><td>89</td></tr>
<tr><td>Oakland</td><td>191</td></tr>
<tr><td>San Diego</td><td>0</td></tr>
<tr><td>Hueneme</td><td>0</td></tr>
</table></td><td>Includes visits from vessels in fleets not subject to the existing At-Berth Regulation, or from non-shore power-capable vessels in currently regulated fleets.</td></tr>
</table>

<table>
<tr>
<td rowspan="2"></td>
<td>
<table>
<tr><td>Total:</td><td>403</td></tr>
</table>
</td>
<td>These vessel visit counts are further adjusted below to account for flexibility provisions prior to being used to calculate costs.</td>
</tr>
<tr>
<td>
<table>
<tr><th rowspan="2">Port</th><th colspan="2">Annual visits from vessels not anticipated to install shore power</th></tr>
<tr><th>Proposed Regulation & Alternative 2</th><th>Alternative 1</th></tr>
<tr><td>Los Angeles</td><td>21</td><td>21</td></tr>
<tr><td>Long Beach</td><td>34</td><td>24</td></tr>
<tr><td>Oakland</td><td>0</td><td>0</td></tr>
<tr><td>San Diego</td><td>0</td><td>0</td></tr>
<tr><td>Hueneme</td><td>0</td><td>0</td></tr>
<tr><td>Total:</td><td>55</td><td>45</td></tr>
</table>
</td>
<td>Includes visits from vessels that do not currently have shore power and are not anticipated to install it due to the Proposed Regulation because they do not meet the filters described in **Table XI.**

These vessel visit counts are equal to the number of visits Staff anticipates would use capture and control systems under the Proposed Regulation and Alternative 2. Under Alternative 1, Staff anticipates these visits would be covered by TIEs/VIEs.</td>
</tr>
<tr>
<td rowspan="2">Annual vessel visits with exceptions, TIEs/VIEs or remediation fund provisions.

These vessel visit counts are used to calculate shore power energy costs, fuel savings, LCFS credits and labor costs, and hourly capture and control barge costs, as</td>
<td>
<table>
<tr><th rowspan="2">Port</th><th colspan="2">Newly regulated vessel visits adjusted for non-shore power vessels, exceptions, remediation (All Years)</th></tr>
<tr><th>Proposed Regulation & Alternative 2</th><th>Alternative 1</th></tr>
<tr><td>Los Angeles</td><td>60</td><td>60</td></tr>
<tr><td>Long Beach</td><td>18</td><td>28</td></tr>
<tr><td>Oakland</td><td>125</td><td>125</td></tr>
<tr><td>San Diego</td><td>0</td><td>0</td></tr>
<tr><td>Hueneme</td><td>0</td><td>0</td></tr>
<tr><td>Total:</td><td>202</td><td>212</td></tr>
</table>
</td>
<td>Visits from non-shore power vessels, safety and commissioning exceptions and remediation visits are subtracted from the unadjusted “newly regulated vessel visits.”

This is the number of vessel visits used to calculate shore power labor costs.</td>
</tr>
<tr>
<td>
<table>
<tr><th rowspan="2">Port</th><th colspan="2">Newly regulated vessel visits adjusted for non-shore power vessels, exceptions, TIE/VIEs, remediation: All Scenarios</th></tr>
<tr><th>2021 - 2022</th><th>2023 - 2032</th></tr>
<tr><td>Los Angeles</td><td>0</td><td>0</td></tr>
<tr><td>Long Beach</td><td>0</td><td>0</td></tr>
<tr><td>Oakland</td><td>0</td><td>29</td></tr>
<tr><td>San Diego</td><td>0</td><td>0</td></tr>
</table>
</td>
<td>Visits from non-shore power vessels, safety and commissioning exceptions, TIE/VIEs, and remediation visits are subtracted from the unadjusted “newly regulated vessel visits.”

This is the number of vessel visits used to calculate shore power energy costs, fuel savings and LCFS credits.</td>
</tr>
</table>

<table>
<tr><td rowspan="2">described in the “Basis” column.</td><td><table><tr><td>Hueneme</td><td>0</td><td>0</td></tr><tr><td>Total:</td><td>0</td><td>29</td></tr></table></td><td></td></tr>
<tr><td><table><tr><th>Port</th><th>Barge-based capture and control visits: Proposed Regulation & Alternative 2 (All Years)</th></tr><tr><td>Los Angeles</td><td>21</td></tr><tr><td>Long Beach</td><td>34</td></tr><tr><td>Oakland</td><td>0</td></tr><tr><td>San Diego</td><td>0</td></tr><tr><td>Hueneme</td><td>0</td></tr><tr><td>Total:</td><td>55</td></tr></table></td><td>Based on Staff’s Berth Analysis, these numbers are equal to the number of vessel visits from vessels not expected to install shore power in response to the Proposed Regulation or alternatives.

This is the number of vessel visits used to calculate hourly capture and control barge costs.</td></tr>
</table>

Table XIII-B. Annual Vessel Visits – Cruise

<table>
<tr><th>Data Input</th><th>Value</th><th>Basis</th></tr>
<tr><td rowspan="2">Annual vessel visits <u>without exceptions, TIEs/VIEs or remediation fund provisions.</u></td><td><table><tr><th>Port</th><th>All annual vessel visits</th></tr><tr><td>Los Angeles</td><td>101</td></tr><tr><td>Long Beach</td><td>256</td></tr><tr><td>San Francisco</td><td>81</td></tr><tr><td>San Diego</td><td>89</td></tr><tr><td>Total:</td><td>527</td></tr></table></td><td>Includes all vessel visits that would be controlled under the Proposed Regulation or alternatives, based on 2017 CSLC data. These visits are equal to all vessel visits in California based off of 2017 data.

This is the base number of vessel visits used for each year of the cost analysis. To account for the potential of increased vessel visits over the analysis period, Staff applied annual industry growth factors as described in **Table I**.

These vessel visit counts are used to calculate the administrative costs of preparing and submitting vessel visit reports.</td></tr>
<tr><td><table><tr><th>Port</th><th>Newly regulated vessel visits</th></tr><tr><td>Los Angeles</td><td>22</td></tr><tr><td>Long Beach</td><td>0</td></tr></table></td><td>Includes visits from vessels in fleets not subject to the existing At-Berth Regulation, or</td></tr>
</table>

<table>
<tr>
<td rowspan="2"></td>
<td>
<table>
<tr><td>San Francisco</td><td>28</td></tr>
<tr><td>San Diego</td><td>16</td></tr>
<tr><td>Total:</td><td>66</td></tr>
</table>
</td>
<td>from non-shore power capable vessels in currently regulated fleets.

Staff updated the newly regulated vessel visits from the CSLC data for the Port of San Francisco based on the Port’s comment letter dated May 29, 2019.

These vessel visit counts are further adjusted below to account for flexibility provisions prior to being used to calculate costs.</td>
</tr>
<tr>
<td>
<table>
<tr><th>Port</th><th>Annual visits from vessels not anticipated to install shore power: All Scenarios</th></tr>
<tr><td>Los Angeles</td><td>0</td></tr>
<tr><td>Long Beach</td><td>0</td></tr>
<tr><td>San Francisco</td><td>0</td></tr>
<tr><td>San Diego</td><td>0</td></tr>
<tr><td>Total:</td><td>0</td></tr>
</table>
</td>
<td>Includes visits from vessels that do not currently have shore power and would not be anticipated to install it in response to the Proposed Regulation or alternatives.

Note: Staff assumes all cruise vessels that do not currently have shore power would install it in response to the Proposed Regulation or alternatives.</td>
</tr>
<tr>
<td>Annual vessel visits with exceptions, TIEs/VIEs or remediation fund provisions.

These vessel visit counts are</td>
<td>
<table>
<tr><th>Port</th><th>Newly regulated vessel visits adjusted for exceptions and remediation: All Scenarios (All Years)</th></tr>
<tr><td>Los Angeles</td><td>18</td></tr>
<tr><td>Long Beach</td><td>0</td></tr>
<tr><td>San Francisco</td><td>25</td></tr>
<tr><td>San Diego</td><td>12</td></tr>
<tr><td>Total:</td><td>55</td></tr>
</table>
</td>
<td>Visits from safety and commissioning exceptions and remediation visits are subtracted from the unadjusted “newly regulated vessel visits.”

This is the number of vessel visits used to calculate shore power labor costs.</td>
</tr>
</table>

<table>
<tr>
<td>used to calculate shore power energy costs, fuel savings, LCFS credits and labor costs, as described in the “Basis” column.</td>
<td>
<table>
<tr><th rowspan="2">Port</th><th colspan="2">Newly regulated vessel visits adjusted for exceptions, TIE/VIEs, remediation: All Scenarios</th></tr>
<tr><th>2021 - 2022</th><th>2023 - 2032</th></tr>
<tr><td>Los Angeles</td><td>8</td><td>12</td></tr>
<tr><td>Long Beach</td><td>0</td><td>0</td></tr>
<tr><td>San Francisco</td><td>17</td><td>20</td></tr>
<tr><td>San Diego</td><td>3</td><td>7</td></tr>
<tr><td>Total:</td><td>28</td><td>39</td></tr>
</table>
</td>
<td>Visits from safety and commissioning exceptions, TIE/VIEs, and remediation visits are subtracted from the unadjusted “newly regulated vessel visits.”
This is the number of vessel visits used to calculate shore power energy costs, fuel savings and LCFS credits.</td>
</tr>
</table>

Table XIII-C. Annual Vessel Visits – Ro-Ro

<table>
<tr><th>Data Input</th><th>Value</th><th>Basis</th></tr>
<tr>
<td>Annual vessel visits <u>without exceptions, TIEs/VIEs or remediation fund provisions.</u></td>
<td>
<table>
<tr><th>Port/Marine Terminal</th><th>All annual vessel visits</th></tr>
<tr><td>Los Angeles</td><td>94</td></tr>
<tr><td>Long Beach</td><td>211</td></tr>
<tr><td>San Francisco</td><td>26</td></tr>
<tr><td>San Diego</td><td>253</td></tr>
<tr><td>Hueneme</td><td>240</td></tr>
<tr><td>Richmond Area</td><td>71</td></tr>
<tr><td>Carquinez Area</td><td>122</td></tr>
<tr><td>Total:</td><td>1,017</td></tr>
</table>
</td>
<td>Includes all vessel visits that would be controlled under the Proposed Regulation or alternatives, based on 2017 CSLC data. These visits are equal to all vessel visits in California based off of 2017 data.
This is the base number of vessel visits used for each year of the cost analysis. To account for the potential of increased vessel visits over the analysis period, Staff applied annual industry growth factors as described in Table I.
These vessel visit counts are used to calculate the administrative costs of preparing and submitting vessel visit reports.</td>
</tr>
<tr>
<td>Annual vessel visits <u>with exceptions, TIEs/VIEs or</u></td>
<td>
<table>
<tr><th>Port/Marine Terminal</th><th><u>Barge-based</u> capture and control visits: Proposed Regulation (All Years)*</th></tr>
<tr><td>Los Angeles</td><td>90</td></tr>
</table>
</td>
<td>Land-based capture and control visits are assumed only where Staff’s Berth Analysis indicated barge-based capture and control technology would likely be used. At ports/marine terminals where Staff assumes</td>
</tr>
</table>

<table>
<tr>
<td rowspan="3"><u>remediation fund provisions.</u>

These vessel visit counts are used to calculate capture and control costs and shore power energy costs, fuel savings, LCFS credits and labor costs (for Alternative 1), as described in the “Basis” column.</td>
<td><table>
<tr><td>Long Beach</td><td>103</td></tr>
<tr><td>San Francisco</td><td>25</td></tr>
<tr><td>San Diego</td><td>196</td></tr>
<tr><td>Hueneme</td><td>0</td></tr>
<tr><td>Richmond Area</td><td>68</td></tr>
<tr><td>Carquinez Area</td><td>117</td></tr>
<tr><td>Total:</td><td>599</td></tr>
</table>
*Barge-based capture and control visits + land-based capture and control visits = total annual vessel visits adjusted for exceptions and remediation.</td>
<td>only barge-based systems would be used, this number equals all annual vessel visits with safety and commissioning exceptions and remediation visits removed. At ports/marine terminals where Staff assumes both barge and land based systems would be used, <u>half</u> of the annual visits are assumed to use barges.

Hourly barge costs are calculated from this number of visits and the hourly barge utilization fee listed in Table II.</td>
</tr>
<tr>
<td><table>
<tr><th>Port/Marine Terminal</th><th><u>Land-based</u> capture and control visits: Proposed Regulation (All Years)*</th></tr>
<tr><td>Los Angeles</td><td>0</td></tr>
<tr><td>Long Beach</td><td>100</td></tr>
<tr><td>San Francisco</td><td>0</td></tr>
<tr><td>San Diego</td><td>47</td></tr>
<tr><td>Hueneme</td><td>230</td></tr>
<tr><td>Richmond Area</td><td>0</td></tr>
<tr><td>Carquinez Area</td><td>0</td></tr>
<tr><td>Total:</td><td>377</td></tr>
</table>
*Barge-based capture and control visits + land-based capture and control visits = total annual vessel visits adjusted for exceptions and remediation.</td>
<td>Land-based capture and control visits are assumed only where Staff’s Berth Analysis indicated land-based capture and control technology may be used. At ports/marine terminals where Staff assumes only land-based systems would be used, this number equals all annual vessel visits with safety and commissioning exceptions and remediation visits removed. At ports/marine terminals where Staff assumes both barge and land based systems would be used, <u>half</u> of the visits are assumed to use land-based systems.

Since Staff assumes land-based systems would be purchased by terminals, only labor costs are calculated from this number of vessel visits.</td>
</tr>
<tr>
<td><table>
<tr><th>Port/Marine Terminal</th><th>All vessel visits adjusted for exceptions, remediation (All Years)</th></tr>
<tr><td>Los Angeles</td><td>90</td></tr>
</table></td>
<td>Visits from safety and commissioning exceptions and remediation visits are subtracted from the unadjusted “all annual vessel visits.”</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td>
<table>
<tr><td>Long Beach</td><td>202</td></tr>
<tr><td>San Francisco</td><td>25</td></tr>
<tr><td>San Diego</td><td>243</td></tr>
<tr><td>Hueneme</td><td>230</td></tr>
<tr><td>Richmond Area</td><td>68</td></tr>
<tr><td>Carquinez Area</td><td>117</td></tr>
<tr><td>Total:</td><td>975</td></tr>
</table>
</td>
<td>This is the number of vessel visits used to calculate shore power labor costs for Alternative 1.</td>
</tr>
<tr>
<td></td>
<td>
<table>
<tr><td>Port/Marine Terminal</td><td colspan="2">All vessel visits adjusted for exceptions, TIE/VIEs, remediation</td></tr>
<tr><td></td><td>2025</td><td>2026 - 2032</td></tr>
<tr><td>Los Angeles</td><td>81</td><td>84</td></tr>
<tr><td>Long Beach</td><td>181</td><td>190</td></tr>
<tr><td>San Francisco</td><td>22</td><td>23</td></tr>
<tr><td>San Diego</td><td>217</td><td>227</td></tr>
<tr><td>Hueneme</td><td>206</td><td>216</td></tr>
<tr><td>Richmond Area</td><td>61</td><td>64</td></tr>
<tr><td>Carquinez Area</td><td>105</td><td>110</td></tr>
<tr><td>Total:</td><td>873</td><td>914</td></tr>
</table>
</td>
<td>Visits from safety and commissioning exceptions, TIE/VIEs, and remediation visits are subtracted from the unadjusted “all annual vessel visits.”

This is the number of vessel visits used to calculate land-based capture and control operational costs for the Proposed Regulation and shore power energy costs, fuel savings and LCFS credits for Alternative 1.</td>
</tr>
</table>

Table XIII-D. Annual Vessel Visits – Tankers

<table>
<tr><th>Data Input</th><th>Value</th><th>Basis</th></tr>
<tr>
<td>Annual vessel visits subject to vessel visit reporting requirements.</td>
<td>
<table>
<tr><td>All annual tanker vessel visits</td></tr>
<tr><td>1,615</td></tr>
</table>
</td>
<td>All tanker vessel visits in California including those that would not be controlled under the Proposed Regulation or alternatives, based on 2017 CSLC data.

These vessel visit counts are only used to calculate the administrative costs of preparing and submitting vessel visit reports.</td>
</tr>
</table>

<table>
<tr>
<td>Annual vessel visits without exceptions, TIEs/VIEs or remediation fund provisions.</td>
<td>
<table>
<tr><th>Port/Marine Terminal</th><th>All annual vessel visits</th></tr>
<tr><td>Los Angeles</td><td>187</td></tr>
<tr><td>Long Beach</td><td>359</td></tr>
<tr><td>Stockton Area</td><td>34</td></tr>
<tr><td>Richmond Area</td><td>391</td></tr>
<tr><td>Carquinez Area</td><td>241</td></tr>
<tr><td>Rodeo Area</td><td>108</td></tr>
<tr><td>Total:</td><td>1,320
(POLA/POLB: 546)
(all other terminals: 774)</td></tr>
</table>
</td>
<td>Includes all vessel visits that would be controlled under the Proposed Regulation or alternatives, based on 2017 CSLC data.

This is the base number of vessel visits used for each year of the cost analysis. To account for the potential of increased vessel visits over the analysis period, Staff applied annual industry growth factors as described in Table I.</td>
</tr>
<tr>
<td rowspan="2">Annual vessel visits with exceptions, TIEs/VIEs or remediation fund provisions.

These vessel visit counts are used to calculate capture and control costs and shore power energy costs, fuel savings, LCFS credits and labor costs (for Alternative 1), as described in the “Basis” column.</td>
<td>
<table>
<tr><th>Port/Marine Terminal</th><th>Land-based capture and control visits, Proposed Regulation & Alternative 2 (Year 2027: POLA/POLB and Year 2029: all other terminals)</th></tr>
<tr><td>Los Angeles</td><td>179</td></tr>
<tr><td>Long Beach</td><td>344</td></tr>
<tr><td>Stockton Area</td><td>33</td></tr>
<tr><td>Richmond Area</td><td>375</td></tr>
<tr><td>Carquinez Area</td><td>231</td></tr>
<tr><td>Rodeo Area</td><td>104</td></tr>
<tr><td>Total:</td><td>1,265</td></tr>
</table>
</td>
<td>Visits from safety and commissioning exceptions and remediation visits are subtracted from the unadjusted “all annual vessel visits.”

Since Staff assumes land-based systems would be purchased by terminals, only labor costs are calculated from this number of vessel visits.</td>
</tr>
<tr>
<td>
<table>
<tr><th>Port/Marine Terminal</th><th>All vessel visits adjusted for exceptions, remediation (Year 2027: POLA/POLB and Year 2029: all other terminals)</th></tr>
<tr><td>Los Angeles</td><td>179</td></tr>
<tr><td>Long Beach</td><td>344</td></tr>
<tr><td>Stockton Area</td><td>33</td></tr>
<tr><td>Richmond Area</td><td>375</td></tr>
<tr><td>Carquinez Area</td><td>231</td></tr>
<tr><td>Rodeo Area</td><td>104</td></tr>
<tr><td>Total:</td><td>1,265</td></tr>
</table>
</td>
<td>This number equals “all annual vessel visits” with safety and commissioning exceptions and remediation visits removed.

This is the number of vessel visits used to calculate shore power labor costs for Alternative 1.</td>
</tr>
</table>

<table>
<tr>
<td></td>
<td>
<table>
<tr><th rowspan="2">Port/Marine Terminal</th><th colspan="2">All annual vessel visits adjusted for exceptions, TIE/VIEs, remediation</th></tr>
<tr><th>2027: POLA/POLB and 2029: all other terminals</th><th>2028 – 2032: POLA/POLB and 2030 – 2032: all other terminals</th></tr>
<tr><td>Los Angeles</td><td>160</td><td>168</td></tr>
<tr><td>Long Beach</td><td>308</td><td>322</td></tr>
<tr><td>Stockton Area</td><td>29</td><td>31</td></tr>
<tr><td>Richmond Area</td><td>336</td><td>351</td></tr>
<tr><td>Carquinez Area</td><td>207</td><td>217</td></tr>
<tr><td>Rodeo Area</td><td>93</td><td>97</td></tr>
<tr><td>Total:</td><td>1,133</td><td>1,186</td></tr>
</table>
</td>
<td></td>
<td>
<p>This number equals “all annual vessel visits” with safety and commissioning exceptions, TIEs/VIEs, and remediation visits removed.</p>
<p>This is the number of vessel visits used to calculate capture and control operational costs for the Proposed Regulation and shore power energy costs, fuel savings and LCFS credits for Alternative 1.</p>
</td>
</tr>
</table>

Table XIII-E. Annual Vessel Visits – Bulk/General

Data Input	Value	Basis
Annual vessel visits subject to vessel visit reporting requirements.	All annual bulk/general vessel visits 830	All bulk/general vessel visits in California, based on 2017 CSLC data. These vessels would not be controlled under the Proposed Regulation or alternatives. These vessel visit counts are only used to calculate the administrative costs of preparing and submitting vessel visit reports.

Table XIV. Flexibility Adjustments

<table>
<tr><th>Data Input</th><th>Value</th><th>Basis</th></tr>
<tr>
<td>Percent of visits to a terminal allowed as a Terminal Incident Event (TIE) or Vessel Incident Event (VIE) (combined)</td>
<td>
<table>
<tr><th>Vessel Category</th><th>2021 - 2022</th><th>2023 - 2024</th><th>2025</th><th>2026</th></tr>
<tr><td>Container/ Reefer</td><td>10%</td><td>6%</td><td>6%</td><td>6%</td></tr>
<tr><td>Cruise</td><td>10%</td><td>6%</td><td>6%</td><td>6%</td></tr>
<tr><td>Ro-Ro</td><td>--</td><td>--</td><td>10%</td><td>6%</td></tr>
<tr><td>Tankers (POLA/POLB)</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td>Tankers (all other terminals)</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
</table>
<table>
<tr><th>Vessel Category</th><th>2027</th><th>2028</th><th>2029</th><th>2030 - 2032</th></tr>
<tr><td>Container/ Reefer</td><td>6%</td><td>6%</td><td>6%</td><td>6%</td></tr>
<tr><td>Cruise</td><td>6%</td><td>6%</td><td>6%</td><td>6%</td></tr>
<tr><td>Ro-Ro</td><td>6%</td><td>6%</td><td>6%</td><td>6%</td></tr>
</table>
</td>
<td>Proposed Regulation
These percentages are applied to adjust the annual vessel visits that are used to calculate specific costs as described in Tables XIII-A through XIII-D.</td>
</tr>
</table>

<table>
<tr><td></td><td><table>
<tr><td>Tankers (POLA/POLB)</td><td>10%</td><td>6%</td><td>6%</td><td>6%</td></tr>
<tr><td>Tankers (all other terminals)</td><td>--</td><td>--</td><td>10%</td><td>6%</td></tr>
</table></td><td></td></tr>
<tr><td>Percent of visits to a terminal categorized as safety/emergency exception</td><td>0.62% of all vessel visits</td><td>Based on Staff analysis of 2017 CARB Enforcement data documenting reasons vessels failed to connect to shore power. Container, Reefer, and Cruise vessels reported safety events for 21 out of 3,424 visits from shore power-capable vessels.</td></tr>
<tr><td>Percentage of visits to a terminal categorized as a commissioning exception</td><td>3% of all vessel visits</td><td>Based on Staff analysis of 2017 CARB Enforcement data documenting reasons vessels failed to connect to shore power.</td></tr>
<tr><td>Percentage of vessel visits assumed to use remediation</td><td><table>
<tr><th>Vessel Type</th><th>% Visits Terminal Upgrades</th><th>% Visits Vessel Equipment Repair</th></tr>
<tr><td>Container/ Reefer</td><td>0.50%</td><td>0%</td></tr>
<tr><td>Cruise</td><td>0.50%</td><td>0%</td></tr>
<tr><td>Auto/Ro-Ro</td><td>0.50%</td><td>0%</td></tr>
<tr><td>Tankers (POLA/POLB)</td><td>0.50%</td><td>0.17%</td></tr>
<tr><td>Tankers (all other terminals)</td><td>0.50%</td><td>0%</td></tr>
</table></td><td>Remediation visits calculated as a percentage of total vessel visits, based on 2017 CARB Enforcement data documenting reasons vessels failed to connect to shore power. In 2017 there were 17 out of 3,424 instances of terminal or port construction preventing shore power connection, and one vessel visit that would have been expected to use the remediation fund option under the Proposed Regulation.</td></tr>
</table>

Table XV. Remediation Costs

<table>
<tr><th>Data Input</th><th>Value</th><th>Basis</th></tr>
<tr><td>Hourly remediation cost for terminal and for vessel, for each vessel type</td><td><table><tr><th>Vessel Type</th><th>Vessel Hourly Cost</th><th>Terminal Hourly Cost</th></tr><tr><td>Container/Reefer</td><td>$2,395</td><td>$2,395</td></tr><tr><td>Cruise</td><td>$12,879</td><td>$12,879</td></tr><tr><td>Auto/Ro-Ro</td><td>$1,515</td><td>$1,515</td></tr><tr><td>Product Tankers</td><td>$1,783</td><td>$1,783</td></tr><tr><td>Crude Tankers</td><td>$9,873</td><td>$9,873</td></tr></table></td><td>Staff analysis using Carl Moyer formula to calculate average emissions in tons per hour by vessel category. Product and crude tanker values were averaged for cost estimation purposes, however the fee would be dependent on the vessel type. Note that these values are estimates based on current Staff analyses at the time this document was prepared, and do not necessarily represent the exact fees that would apply.</td></tr>
<tr><td>Which terminals would offer the remediation fund as an option?</td><td>All (100%)</td><td>Staff assumes that all terminals would offer the remediation fund as an option.</td></tr>
</table>

APPENDIX B
Proposed Control Measure for Ocean-Going Vessels Operating At Berth
Cost Analysis for Standardized Regulatory Impact Assessment
August 1, 2019

CALIFORNIA
AIR RESOURCES BOARD

This document was prepared by California Air Resources Board (CARB) Staff to calculate preliminary cost estimates for the Proposed Control Measure for Ocean-Going Vessels At Berth (Proposed Regulation). Staff is developing these 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.

Regulatory Scenarios Considered in Cost Analysis:

Proposed Regulation

Alternative 1: Shore power required for all vessel types (no capture and control)

Alternative 2: Same as Draft Regulation, except ro-ro vessels (which includes auto vessels) not subject to emission control requirements

Control Measure for Ocean-Going Vessels Operating At Berth

Cost Analysis for Standardized Regulatory Impact Assessment

Content	**Tab**	**Description**
Summary Tables	Summary	Annual and total costs by vessel category for Proposed Regulation and Alternatives
	Relative Costs	Summary of Costs as a Percentage of Total Costs
Data Inputs	Cost Inputs	Inputs for capture and control system and infrastructure costs, shore power infrastructure costs, and administrative costs
	Electricity & Fuel	Engine effective power values, duration of emission control, electricity and fuel cost projections and LCFS credit value projections
	Growth	Annual industry growth factors by vessel type
	Apportion	Percentage of capital costs apportioned to ports and terminals
	Berths, Terminals, Vessels	Terminal and berth counts by port/Area IMTs, anticipated infrastructure needs, and unique vessel counts
	Exceptions & Events	Annual estimated exceptions, Terminal Incident Events (TIEs) Vessel Incident Events (VIEs), remediation fee visits, and remediation fee amounts
	Vessel Visits	Total annual vessel visits by vessel type, and vessel visits adjusted for exceptions, TIEs, and remediation fee visits
Calculations	C&C - Container & Ro-Ro	Barge-based and land-based capture and control system capital costs, operating costs, CARB approval costs, and hourly fee costs for Container/Reefer and Ro-Ro terminals and vessels
	C&C - Tankers	Land-based capture and control system capital costs, operating costs, CARB approval costs, feasibility, engineering, and permitting costs for Tanker terminals and vessels
	SP Berth Retrofit	Shore power berth retrofit capital and maintenance costs
	SP Vessel Retrofit	Shore power vessel retrofit capital and maintenance costs
	SP Labor & Energy	Shore power labor & energy costs and cost savings
	Admin	Annual reporting and plan development costs, CARB PY costs, and other agency PY costs
	Remediation	Remediation fee costs
Analysis	POLB Analysis	Estimated costs for Port of Long Beach
	Hueneme Analysis	Estimated costs for Port of Hueneme

Summary of Relative Costs

Proposed Regulation

Cost Parameter	Total 2020 - 2032	% of Total
Land-Based Capture and Control Annualized Capital Costs	*$1,129,251,535*	*48%*
Land-Based Capture and Control System Labor Costs	*$163,182,617*	*7%*
Land-Based Capture and Control System Maintenance Costs	*$32,064,954*	*1%*
Land-Based Capture and Control Operational Costs	*$104,481,153*	*4%*
Land-Based Capture and Control System Feasibility Study Costs	*$15,000,000*	*1%*
Land-Based Capture and Control System Engineering Costs	*$210,064,287*	*9%*
Land-Based Capture and Control System Permitting Costs	*$70,021,429*	*3%*
Land-Based Capture and Control System Performance Testing	*$2,090,062*	*0%*
Hourly Barge-Based Capture and Control Usage Fees	*$149,703,802*	*6%*
Shore Power Berth Retrofit Capital Costs	*$141,050,316*	*6%*
Shore Power Berth Retrofit Maintenance Costs	*$886,905*	*0%*
Shore Power Vessel Retrofit Capital Costs	*$216,600,630*	*9%*
Shore Power Vessel Retrofit Maintenance Costs	*$14,101,309*	*1%*
Shore Power Electricity Costs	*$17,951,177*	*1%*
Shore Power Labor Costs	*$10,661,952*	*0%*
Shore Power Fuel Savings	*-$19,672,172*	*-1%*
Shore Power LCFS Credit Value	*-$6,253,225*	*0%*
Cost of Port Plans	*$610,737*	*0%*
Cost of Terminal Plans	*$490,282*	*0%*
Cost of Vessel Reporting	*$12,482,076*	*1%*
Cost of Terminal Reporting	*$12,482,076*	*1%*
Remediation Fee Visit Costs	*$48,641,669*	*2%*
PY Costs	*$23,516,000*	*1%*
Total	*$2,349,409,572*	*1.00*

Summary of Annualized Costs by Vessel Type

Proposed Regulation

Year	Container/ Reefer	Cruise	Ro-Ro	All Tankers	Bulk/General Cargo	Total - All Vessel Types
2020	$8,255,000	$13,706,000	$138,000	$15,107,000	$0	$37,206,000
2021	$15,639,000	$15,504,000	$498,000	$16,403,000	$209,000	$48,253,000
2022	$15,926,000	$15,990,000	$396,000	$43,494,000	$209,000	$76,014,000
2023	$16,172,000	$16,652,000	$435,000	$43,496,000	$209,000	$76,964,000
2024	$16,745,000	$17,220,000	$1,499,000	$87,350,000	$209,000	$123,022,000
2025	$17,448,000	$17,836,000	$16,053,000	$87,719,000	$209,000	$139,264,000
2026	$18,232,000	$18,457,000	$16,519,000	$186,066,000	$209,000	$239,482,000
2027	$18,740,000	$19,107,000	$17,027,000	$194,806,000	$209,000	$249,888,000
2028	$19,197,000	$19,761,000	$17,410,000	$196,575,000	$209,000	$253,152,000
2029	$19,694,000	$20,439,000	$17,801,000	$212,182,000	$209,000	$270,325,000
2030	$20,233,000	$21,149,000	$18,202,000	$214,444,000	$209,000	$274,235,000
2031	$20,890,000	$21,863,000	$18,612,000	$216,935,000	$209,000	$278,509,000
2032	$21,833,000	$22,614,000	$19,047,000	$219,392,000	$209,000	$283,095,000
Total	$229,004,000	$240,298,000	$143,635,000	$1,733,969,000	$2,503,000	$2,349,410,000

Alternative 1

Year	Container/ Reefer	Cruise	Ro-Ro	All Tankers	Bulk/General Cargo	Total - All Vessel Types
2020	$8,869,000	$13,706,000	$138,000	$10,640,000	$0	$33,353,000
2021	$14,169,000	$15,504,000	$138,000	$11,936,000	$209,000	$41,956,000
2022	$14,404,000	$15,990,000	$498,000	$25,413,000	$209,000	$56,514,000
2023	$14,594,000	$16,652,000	$396,000	$25,415,000	$209,000	$57,266,000
2024	$15,107,000	$17,220,000	$147,346,000	$60,465,000	$209,000	$240,346,000
2025	$15,747,000	$17,836,000	$149,544,000	$60,764,000	$209,000	$244,100,000
2026	$16,434,000	$18,457,000	$153,355,000	$254,487,000	$209,000	$442,941,000
2027	$16,897,000	$19,107,000	$157,449,000	$244,402,000	$209,000	$438,064,000
2028	$17,307,000	$19,761,000	$160,723,000	$246,373,000	$209,000	$444,373,000
2029	$17,752,000	$20,439,000	$164,039,000	$230,735,000	$209,000	$433,173,000

2030	$18,234,000	$21,149,000	$167,490,000	$232,407,000	$209,000	$439,488,000
2031	$18,833,000	$21,863,000	$170,869,000	$234,266,000	$209,000	$446,039,000
2032	$19,677,000	$22,614,000	$174,540,000	$236,386,000	$209,000	$453,426,000
Total	$208,025,000	$240,298,000	$1,446,525,000	$1,873,688,000	$2,503,000	$3,771,038,000

Alternative 2

Year	Container/ Reefer	Cruise	Ro-Ro	All Tankers	Bulk/General Cargo	Total - All Vessel Types
2020	$8,255,000	$13,706,000	$0	$15,107,000	$0	$37,068,000
2021	$15,639,000	$15,504,000	$234,000	$16,403,000	$209,000	$47,989,000
2022	$15,926,000	$15,990,000	$241,000	$43,494,000	$209,000	$75,859,000
2023	$16,172,000	$16,652,000	$248,000	$43,496,000	$209,000	$76,777,000
2024	$16,745,000	$17,220,000	$255,000	$87,350,000	$209,000	$121,779,000
2025	$17,448,000	$17,836,000	$263,000	$87,719,000	$209,000	$123,474,000
2026	$18,232,000	$18,457,000	$270,000	$186,066,000	$209,000	$223,233,000
2027	$18,740,000	$19,107,000	$276,000	$194,806,000	$209,000	$233,137,000
2028	$19,197,000	$19,761,000	$283,000	$196,575,000	$209,000	$236,025,000
2029	$19,694,000	$20,439,000	$289,000	$212,182,000	$209,000	$252,813,000
2030	$20,233,000	$21,149,000	$296,000	$214,444,000	$209,000	$256,329,000
2031	$20,890,000	$21,863,000	$303,000	$216,935,000	$209,000	$260,200,000
2032	$21,833,000	$22,614,000	$310,000	$219,392,000	$209,000	$264,358,000
Total	$229,004,000	$240,298,000	$3,268,000	$1,733,969,000	$2,503,000	$2,209,042,000

Cost Inputs

Formatting Legend
Original Input
Value linked from another cell or tab
Calculation

Barge-Based Capture and Control

	Unit	Value
Hourly Fee - Container/Reefer, Ro-Ro[A]	Cost per hour ($)	$900

[A] Emails from Ruben Garcia (AEG) to Angela Csondes (CARB) dated 3/27/19 and 4/3/19.

Land-Based Capture and Control - Ro-Ro

	Unit	Value
Land-Based Emission Treatment System Cost - RoRo Terminals [A]	Cost per system ($)	$3,600,000
Labor Costs [B]	Hourly cost per system ($)	$0
Annual Maintenance Costs [A]	Annual cost per system ($)	$17,500
Annual Operating Costs [A]	Cost per hour ($)	$100

[A] Claimed confidential data obtained from industry sources that requested non-attribution.

B] According to Tri-Mer statements at 4/16/19 CARB meeting, no additional labor would be required to run capture-and-control system.

Land-Based Capture and Control - Tankers - POLA/POLB

Land-Based Emission Control System Cost [A]	Cost per berth ($)	$6,517,857
Terminal Infrastructure (Emission Control System connections, electrical, foundation, etc.) [B]	Cost per berth ($)	$7,000,000
Emission Control System Support Structure [C]	Cost per berth ($)	$5,000,000
Terminal Infrastructure (Berth to Emission Control System Piping) Cost [D]	Cost per berth ($)	$4,500,000
Crane Cost [B]	Cost per berth ($)	$7,000,000
Number of Cranes per Berth [E]	#	1
Total Cost of Cranes	Cost per berth ($)	*$7,000,000*
Crane Support Structure [B]	Cost per structure ($)	$10,000,000
Number of Crane Support Structures per Berth [E]	#	1
Total Cost of Crane Support Structures	Cost per berth ($)	*$10,000,000*
Electric Utility Infrastructure Cost [F]	Cost per berth ($)	$0
Labor Costs [G]	Annual cost per berth ($)	$1,000,000

Annual Maintenance Costs [H]	Percent of capital costs	0.3%
Annual Maintenance Costs	Annual cost per berth ($)	*$162,867*
Operating Costs [I]	Hourly cost per visit ($)	$200
Demurrage [F]	Total cost per visit ($)	$0

Land-Based Capture and Control - Tankers - All Other Terminals Statewide

Land-Based Emission Control System Cost [A]	Cost per berth ($)	$6,517,857
Terminal Infrastructure (Emission Control System connections, electrical, foundation, etc.) [B]	Cost per berth ($)	$7,000,000
Emission Control System Support Structure [C]	Cost per berth ($)	$15,000,000
Terminal Infrastructure (Berth to Emission Control System Piping) Cost [D]	Cost per berth ($)	$4,500,000
Crane Cost [B]	Cost per crane ($)	$7,000,000
Number of Cranes per Berth [E]	#	2
Total Cost of Cranes	Cost per berth ($)	*$14,000,000*
Crane Support Structure [B]	Cost per structure ($)	$10,000,000
Number of Crane Support Structures per Berth [E]	#	2
Total Cost of Crane Support Structures	Cost per berth ($)	*$20,000,000*
Electric Utility Infrastructure Cost [F]	Cost per berth ($)	$0
Labor Costs [G]	Annual cost per berth ($)	$1,000,000
Annual Maintenance Costs [H]	Percent of capital costs	0.3%
Annual Maintenance Costs	Annual cost per berth ($)	*$232,145*
Operating Costs [I]	Hourly cost per visit ($)	$500
Demurrage [F]	Total cost per visit ($)	$0

Note: All land-based capture and control cost inputs include construction/installation costs.

[A] Average of two values: 1) $3,500,000 for a 14,000 scfm system (claimed confidential data obtained from an industry source that requested non-attribution), scaled up proportionally to a volumetric flow rate of 31,250 scfm (estimated from the mid-range of a 100,000 - 125,000 scfm design target estimated by Chevron during a meeting with CARB on 6/10/19, for their four berths at Richmond Long Wharf; and 2) $5,000,000 per emission control system cited in WSPA letter to CARB dated 5/30/19.

[B] Letter from WSPA to CARB dated 5/30/19.

[C] Letter from WSPA to CARB dated 5/30/19. This is a mid-range value between $0 - $10,000, since a support structure would not be needed at every berth.
[D] Staff analysis of data from AEG Benicia RoRo AMECS project, ShoreKat project, and EU 2001 VOC control system cost estimates. WSPA members concurred with this value in the May 30, 2019 letter to CARB.
[E] Letter from WSPA to CARB dated 5/30/19. See Inputs and Assumptions document for underlying assumptions.

[F] The potential for this cost to occur was raised by stakeholders, but no stakeholders provided specific information on which to base an assumed cost. Staff understands that these costs would be incurred at some terminals but not others, and be highly dependent on existing conditions at each individual location.
[G] Based on Staff conversations with tanker terminal operators and Tri-Mer. See Inputs and Assumptions document for underlying assumptions.
[H] Staff did not receive consistent information from stakeholders regarding an appropriate value to estimate maintenance costs for both the emission control system and the associated infrasructure. Therefore, Staff assumes maintenance costs would be similar in proportion to project captial costs for shore power projects, calculated at 0.3% as described in the Inputs and Assumptions document.
[I] Based on claimed confidential data from industry sources that requested non-attribution, scaled up according to the assumptions stated in the Inputs and Analysis document.

Land-Based Capture and Control - All Systems

Annual Performance Testing [A]	Cost per system ($)	$12,000
Cost to Obtain Initial CARB Technology Approval [B]	Cost per approval ($)	$150,000
Terminal Equipment Life [A]	years	20
CRF (5%, 20 years) for land-side equipment	fraction	0.0802

[A] Claimed confidential data obtained from industry sources that requested non-attribution. Cost analysis assumes that this cost is incurred for each berth at tanker terminals.
[B] Claimed confidential data obtained from industry sources that requested non-attribution.

Feasibility, Engineering and Permitting Costs for Tanker Terminal Capture and Control and Shore Power Projects - POLA/POLB	Value	Unit	Start Year	
Feasibility Study Cost [A]	$500,000	per berth	2020	
Engineering Costs - Percent Mulitplier for Capital Costs [B]	12%	of project costs		
Engineering Costs - POLA/POLB Tanker Terminals, Capture and Control	*$5,642,143*	per berth	2020	
Engineering Costs - POLA/POLB Tanker Terminals, Shore Power	*$3,838,000*	per berth	2020	Alt. 1 only

Permitting Costs - Percent Multiplier for Capital Costs [C]	4%	of project costs		
Permitting Costs - POLA/POLB Tanker Terminals, Capture and Control	*$1,880,714*	per berth	2020	
Permitting Costs - POLA/POLB Tanker Terminals, Shore Power	*$1,279,333*	per berth	2020	Alt. 1 only

Feasibility, Engineering and Permitting Costs for Tanker Terminal Capture and Control and Shore Power Projects - All Other Statewide	**Value**	**Unit**	**Start Year**	
Feasibility Study Cost [A]	$500,000	per berth	2022	
Engineering Costs - Percent Mulitplier for Capital Costs [B]	12%	of project costs		
Engineering Costs - All Other Terminals Statewide, Capture and Control	*$8,042,143*	per berth	2022	
Engineering Costs - All Other Terminals Statewide, Shore Power	*$3,838,000*	per berth	2022	Alt. 1 only
Permitting Costs - Percent Multiplier for Capital Costs [C]	4%	of project costs		
Engineering Costs - All Other Terminals Statewide, Capture and Control	*$2,680,714*	per berth	2022	
Engineering Costs - All Other Terminals Statewide, Shore Power	*$1,279,333*	per berth	2022	Alt. 1 only

[A] Tri-Mer statements at 4/16/19 CARB meeting

[B] Based on conversations with Chevron and Marathon, as described in Inputs and Assumptions document.

[B] Based on conversations with Chevron, Marathon and Valero, as described in Inputs and Assumptions document.

Timing of Capture and Control Technology CARB Approvals [A]	Year(s) of Approval(s)	# of Approvals
Container/Reefer Vessels	2019 - 2020	1
Cruise Vessels	2019 - 2020	0
Ro-Ro Vessels - Barge-Based	2023 - 2024	1
Ro-Ro Vessels - Land-Based	2023 - 2024	2
POLA/POLB Tankers	2025 - 2026	3
All Other Tankers	2027 - 2028	4

[A] Staff assumption on number and timing of technology approvals

Shore Power Infrastructure, Maintenance and Labor	Unit	Value
Shore Power Retrofit Cost per Berth - Container/Reefer Berths[A]	Cost per berth upgrade ($)	$7,010,813
Shore Power Cost for Additional Vault - Container/Reefer Berths[A]	Cost per new vault ($)	$1,993,255
Shore Power Retrofit Cost per Berth - Cruise Berths[B]	Cost per berth upgrade ($)	$83,200,000
Shore Power Retrofit Cost per Berth - Tanker Vessels [A]	Cost per berth upgrade ($)	$31,983,333
Shore Power Infrastructure Repair Costs after 20 Years[C]	percent	50%
Shore Power Retrofit Cost per Vessel - Container/Reefer Vessels[A]	Cost per vessel upgrade ($)	$878,541
Shore Power Retrofit Cost per Vessel - Cruise Vessels[A]	Cost per vessel upgrade ($)	$1,629,682
Shore Power Retrofit Cost per Vessel - Ro-Ro Vessels[A]	Cost per vessel upgrade ($)	$3,163,500
Shore Power Retrofit Cost per Vessel - Tanker Vessels[A]	Cost per vessel upgrade ($)	$2,504,469
Terminal Cable Reel Capital Costs[D]	Cost per reel ($)	$250,000
Shore Power Connection Labor Costs[A]	Cost per visit ($)	$2,355
Shore Power Terminal Equipment Maintenance Costs - Container/Reefer[A]	Annual Cost per berth upgrade ($)	$24,285
Shore Power Terminal Equipment Maintenance Costs - Cruise [E]	Annual Cost per berth upgrade ($)	$50,000
Shore Power Vessel Equipment Maintenance Costs [A]	Annual Cost per vessel upgrade ($)	$10,000
Year Maintenance Begins - Container/Reefer and Cruise [C]	year	2021
Year Maintenance Begins - Ro-Ro [C]	year	2025
Year Maintenance Begins - POLA/POLB Tanker Terminals [C]	year	2027
Year Maintenance Begins - All Other Tanker Terminals [C]	year	2029
CRF (5%, 10 years) for berths	fraction	0.0802
CRF (5%, 10 years) for vessels	fraction	0.1295

[A] Average of June 2018 survey data, plus an additional cost for the Emission Control System support structure (see Inputs and Assumptions document for details)

[B] Estimate from Port of San Francisco staff received 5/1/19

[C] Staff assumption

[D] Based on Staff conversations with terminal operators

[E] Letter from Port of San Francisco dated 5/29/19

Administrative Cost Inputs	Number	Cost	Year(s)	Assumptions	Due Date

Port Plans - Container/Reefer	Based on # of terminals and berths in "Berths, Terminals, Vessels" tab	$10,000	2020-2021	Plan cost incurred in 12-month period prior to due date	6/1/2021
Port Plans - Cruise			2020-2021		6/1/2021
Port Plans - Ro-Ro			2020-2021		6/1/2021
Port Plans - Tankers (POLA/POLB)			2020-2021		6/1/2021
Port Plans - Tankers (All Other Statewide)			2020-2021		6/1/2021
Terminal Plans - Container/Reefer		$2,500	2020-2021	Plan cost incurred in 12-month period prior to due date	6/1/2021
Terminal Plans - Cruise			2020-2021		6/1/2021
Terminal Plans - Ro-Ro			2020-2021		6/1/2021
Terminal Plans - Tankers (POLA/POLB)			2020-2021		6/1/2021
Terminal Plans - Tankers (All Other Statewide)			2020-2021		6/1/2021
Terminal Plan Updates - Ro-Ro		$2,500	2023-2024	Plan cost incurred in 12-month period prior to due date	6/1/2024
Terminal Plan Updates - Tankers (POLA/POLB)			2025-2026		6/1/2026
Terminal Plan Updates - Tankers (All Other Statewide)			2027-2028		6/1/2028
Terminal Reporting - Container/Reefer	3742	$100	2021 - 2032	Annually for range of years listed	Within 7 days after vessel visit
Terminal Reporting - Cruise	527				
Terminal Reporting - Ro-Ro	1017				
Terminal Reporting - Tankers (POLA/POLB)	610				
Terminal Reporting - Tankers (All Other Statewide)	1005				
Terminal Reporting - Bulk	830				
Terminal Reporting - General	213				
Vessel Reporting - Container/Reefer	3742	$100	2021 - 2032	Annually for range of years listed	
Vessel Reporting - Cruise	527				
Vessel Reporting - Ro-Ro	1017				
Vessel Reporting - Tankers (POLA/POLB)	610				
Vessel Reporting - Tankers (All Other Statewide)	1005				
Vessel Reporting - General	830				
Vessel Reporting - Bulk	213				

CARB PYs [A]

Position	Number of Positions	Year Hired	Cost Year 1	Cost Subsequent
Air Pollution Specialist (Range C) - Enforcement	1	2021	$180,000	*$179,000*
Air Pollution Specialist (Range C) - Enforcement	1	2027	*$180,000*	*$179,000*
Air Resources Technician II - Enforcement	1	2021	$88,000	*$87,000*

Air Resources Engineer (Range D) - TTD	1	2020	$189,000	*$188,000*
Air Pollution Specialist (Range C) - TTD	2	2021	*$180,000*	*$179,000*
Air Resources Technician II - TTD	1	2020	*$88,000*	*$87,000*

[A] PY cost sheet provided by CARB's Office of Economic Policy and Analysis (OEPA)

Other Agency PYs [A]

Agency	Number of Positions	Year Hired	Cost Year 1	Cost Subsequent
California State Lands Commission	2	2021	*$189,000*	*$188,000*
Other State Agencies Combined	1	2021	*$189,000*	*$188,000*
Local Agencies Combined	1	2021	*$189,000*	*$188,000*
Federal Agencies Combined	1	2021	*$189,000*	*$188,000*

[A] Staff estimate based on conversation with CSLC. Staff assumes PY costs similar to CARB ARE Range D

Electricity and Fuel Inputs

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Auxiliary Engine Effective Power Values (kW/hr) and Duration of Emission Control At Berth

Vessel Type	**Effective Power Value (kW/hr) Weighted Average for All Ports/IMTs**	**Duration of Emission Control At Berth (hours)**[C]
Container/Reefer[A]	*1053*	38.8
Passenger Cruise	5620	11.2
Ro-Ro [B]	1159	19.8
Tankers (all) [A]	*944*	40.7

[A] Container/Reefer and Tanker effective power values calculated below

[B] Value for Auto vessels used, due to high relative vessel visits compared to Ro-Ro vessels

[C] Container/Reefer and Cruise values are adjusted for actual shore power utilization times in 2016

	Container/ Reefer			**Tankers (all)**		
Port/IMT	**Weighted average kW/vessel** [A]	**Total Annual Vessel Visits**	**Fraction Vessel Visits**	**Weighted average kW/vessel** [A]	**Total Annual Vessel Visits**	**Fraction Vessel Visits**
Los Angeles	1101	1029	*0.28*	736	187	*0.14*
Long Beach	1057	909	*0.25*	1000	359	*0.27*
Oakland	1052	1597	*0.43*	▨	▨	▨
San Francisco	▨	▨	▨	▨	▨	▨
San Diego	▨	▨	▨	▨	▨	▨

Hueneme	735	155	*0.04*			
Stockton Area				784	34	*0.03*
Richmond Area				981	391	*0.30*
Carquinez Area [B]				979	241	*0.18*
Rodeo Area [C]				953	108	*0.08*
			1.00			*1.00*

[A] Staff calculated weighted average per vessel type/port. Consistent with Draft Inventory Methodology, Table 7.
https://www.arb.ca.gov/msei/ordiesel/draft2019ogvinv.pdf

[B] Average kW of tanker vessels to Benicia, Martinez and Avon

[C] Average kW of tanker vessels to Oleum and Selby terminals

Electricity Rate Growth Projections

Year	**Projected Electricity Rates in ¢/kWh [A]**				**Statewide Average Future Electricity Rate Assumption $/kWh [B]**
Utility:	**PG&E**	**LADWP**	**SDG&E**	**SCE**	
2019	17.9	16.3	20.6	15.7	*$0.18*
2020	17.5	16.5	20.7	15.6	*$0.18*
2021	17.5	16.5	21.1	15.7	*$0.18*
2022	17.5	16.7	20.3	15.7	*$0.18*
2023	17.6	17.5	20.3	15.1	*$0.18*
2024	17.7	17.7	20.3	15.2	*$0.18*
2025	17.5	18.4	20.4	15.4	*$0.18*
2026	17.4	18.1	20.5	15.6	*$0.18*
2027	17.2	18.3	20.7	15.6	*$0.18*
2028	17.2	18.6	20.8	15.6	*$0.18*
2029	17.3	19.0	21.0	15.7	*$0.18*
2030	17.4	19.5	21.3	15.7	*$0.18*
2031					*$0.19*
2032					*$0.19*

[A] Per email from Chris Kavalec (California Energy Commission) to Paul Milkey (CARB) dated 8/27/2018, rates for the

four major utilities are taken from the Mid Case Revised Demand Forecast updated 2/21/2018 (form 2.3) for years 2019-2030. Values for 2031-32 are extrapolated.

[B] The statewide average is applied to all vessel visits except Cruise vessel visits in San Diego

Cruise Vessel Electricity Rates for Port of San Diego Only

Annual Rate 2021 - 2032	$1.16	$/kWh [A]

[A] "Prepared Direct Testimony of Cynthia Fang on Behalf of San Diego Gas & Electric Company, Chapter 4, Before the Public Utilities Commission of the State of California, September 13, 2017" page CF-10

LCFS Credit for Shore Power

Year	Projected LCFS Credit Value ($/kW-hr) [A]
2021	$0.11
2022	$0.11
2023	$0.11
2024	$0.10
2025	$0.10
2026	$0.10
2027	$0.10
2028	$0.10
2029	$0.10
2030	$0.11
2031	$0.11
2032	$0.11

% LCFS Credits Claimed [B]	100%	percent

[A] LCFS Staff Analysis dated 4/12/19

[B] Staff assumption

Auxiliary Engine Fuel Consumption

Brake-Specific Fuel Consumption [A]	217	g/kW-hr

[A] CARB emission inventory methodology document Appendix A, fuel consumption factor for auxiliary engines at berth, distillate fuel.

MGO Price Growth Projections

Current Fuel Price Assumption $/MT	$763.50	4/25/2018 [A]

Year	Projected Diesel Price $/gallon [B]	Annual Growth	Future Fuel Price Assumption $/MT
2016	$2.33	--	
2017	$2.65	*1.14*	*$868*
2018	$2.80	*1.06*	*$918*
2019	$2.91	*1.04*	*$954*
2020	$3.39	*1.16*	*$1,111*
2021	$3.64	*1.07*	*$1,193*
2022	$3.79	*1.04*	*$1,242*
2023	$3.95	*1.04*	*$1,294*
2024	$4.15	*1.05*	*$1,360*
2025	$4.30	*1.04*	*$1,409*
2026	$4.41	*1.03*	*$1,445*
2027	$4.56	*1.03*	*$1,494*
2028	$4.72	*1.04*	*$1,547*
2029	$4.89	*1.04*	*$1,602*
2030	$5.03	*1.03*	*$1,648*
2031	$5.21	*1.04*	*$1,707*
2032	$5.35	*1.03*	*$1,753*

[A] Reference: www.shipandbunker.com, accessed 4/26/19

[B] Reference: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=12-AEO2018&cases=ref2018&sourcekey=0

Industry Growth Factors

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	Annual Growth Rates				Compound Growth Rates			
Year	Container /Reefer [A]	Cruise	Ro-Ro [B]	Tanker	Container/ Reefer	Cruise	Ro-Ro	Tanker
2018	3.87%	3.68%	3.67%	0.48%	3.9%	3.7%	3.7%	0.5%
2019	3.95%	3.68%	3.69%	0.50%	*8.0%*	*7.5%*	*7.5%*	*1.0%*
2020	6.75%	7.87%	3.71%	0.51%	*15.3%*	*16.0%*	*11.5%*	*1.5%*
2021	3.58%	3.68%	3.24%	1.15%	*19.4%*	*20.2%*	*15.1%*	*2.7%*
2022	3.69%	3.68%	2.90%	0.78%	*23.8%*	*24.7%*	*18.4%*	*3.5%*
2023	3.78%	3.68%	2.91%	0.79%	*28.5%*	*29.2%*	*21.9%*	*4.3%*
2024	3.86%	3.68%	2.92%	0.79%	*33.4%*	*34.0%*	*25.4%*	*5.1%*
2025	5.68%	3.68%	2.93%	0.80%	*41.0%*	*38.9%*	*29.1%*	*5.9%*
2026	2.44%	3.68%	2.93%	1.10%	*44.4%*	*44.0%*	*32.9%*	*7.1%*
2027	2.61%	3.68%	2.27%	1.06%	*48.2%*	*49.3%*	*35.9%*	*8.2%*
2028	2.76%	3.68%	2.27%	1.06%	*52.3%*	*54.8%*	*39.0%*	*9.4%*
2029	2.89%	3.68%	2.27%	1.07%	*56.7%*	*60.5%*	*42.2%*	*10.5%*
2030	3.01%	3.68%	2.27%	1.07%	*61.4%*	*66.5%*	*45.4%*	*11.7%*
2031	4.78%	3.68%	2.36%	1.17%	*69.1%*	*72.6%*	*48.9%*	*13.0%*
2032	4.78%	3.68%	2.30%	1.14%	*77.2%*	*78.9%*	*52.3%*	*14.3%*

[A] Container factor used, due to high activity relative to reefer vessels

[B] Auto factor used, due to high activity relative to RoRo vessels

Vessel Category	Vessel Visits Prop. Reg./Alt. 1	Fraction of Total Vessel Visits	Vessel Visits Alternative 2	Fraction of Total Vessel Visits
Container/Reefer	*3742*	*0.57*	*3742*	*0.67*
Cruise	*527*	*0.08*	*527*	*0.09*
Ro-Ro	*1017*	*0.15*	0	*0.00*
POLA/POLB Tankers	*546*	*0.08*	*546*	*0.10*

All Other Tankers	*774*	*0.12*	*774*	*0.14*
	6606	*1.00*	*5589*	*1.00*

Compound Growth Factors Weighted by Vessel Visits - Proposed Regulation and Alternative 1

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
6.46%	*11.98%*	*15.45%*	*18.97%*	*22.68%*	*26.59%*	*32.00%*	*35.18%*	*38.43%*	*41.89%*	*45.55%*	*49.42%*	*55.07%*	*60.94%*

Compound Growth Factors Weighted by Vessel Visits - Alternative 2

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
6.27%	*12.07%*	*15.52%*	*19.07%*	*22.83%*	*26.09%*	*32.53%*	*35.59%*	*38.88%*	*42.41%*	*46.16%*	*50.15%*	*56.20%*	*62.52%*

Cost Apportionment

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PROPOSED REGULATION AND ALTERNATIVE 2

Port/IMT	Shore Power Capital Costs [A],[B]		Shore Power and Land-Based C&C Maintenance Costs [B]		Shore Power and Land-Based C&C Labor Costs [B]		Shore Power Energy Costs [C]		Ro-Ro Land-Based C&C Capital Costs	
	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal
Los Angeles	100%	0%	100%	0%	100%	0%	0%	100%		
Long Beach	100%	0%	0%	100%	0%	100%	0%	100%	100%	0%
Oakland	100%	0%	100%	0%	0%	100%	100%	0%		
San Francisco	100%	0%	100%	0%	0%	100%	0%	100%		
San Diego	100%	0%	100%	0%	0%	100%	0%	100%	0%	100%
Hueneme	100%	0%	100%	0%	0%	100%	0%	100%	100%	0%
Stockton Area										
Richmond Area									0%	100%
Carquinez Area									0%	100%
Rodeo Area										

ALTERNATIVE 1

Port/IMT	Shore Power Capital Costs		Shore Power Maintenance Costs		Shore Power Labor Costs		Shore Power Energy Costs [C]	
	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal
Los Angeles	100%	0%	100%	0%	100%	0%	0%	100%
Long Beach	100%	0%	0%	100%	0%	100%	0%	100%
Oakland	100%	0%	100%	0%	0%	100%	100%	0%
San Francisco	100%	0%	100%	0%	0%	100%	0%	100%

San Diego	100%	0%	100%	0%	0%	100%	0%	100%
Hueneme	100%	0%	100%	0%	0%	100%	0%	100%
Stockton Area	0%	100%	0%	100%	0%	100%	0%	100%
Richmond Area	0%	100%	0%	100%	0%	100%	0%	100%
Carquinez Area	0%	100%	0%	100%	0%	100%	0%	100%
Rodeo Area	0%	100%	0%	100%	0%	100%	0%	100%

[A] Staff anticipates that only container and cruise terminals would use shore power, based on Staff Berth Analysis.

[B] Cost apportionment based on Staff discussions with ports and terminals.

[C] Port of Oakland charges shore power users an hourly fee.

CARB PY Apportionment	**Number of Terminals**	**Percent of Costs Apportioned**
Container/Reefer	*60*	*49%*
Cruise	*11*	*9%*
Ro-'Ro	*21*	*17%*
Tankers - POLA/POLB	*13*	*11%*
Tankers - Other Statewide	*17*	*14%*
Total	*122*	*100%*

[A] Staff assumption that costs would be apportioned by number of terminals for each vessel type

Other Agency PY Apportionment	**Number of Infrastructure Projects**	**Percent of Costs Apportioned**
Container/Reefer	*5*	*14%*
Cruise	*1*	*3%*
Ro-Ro	*0*	*0%*
Tankers - POLA/POLB	*13*	*36%*
Tankers - Other Statewide	*17*	*47%*
Total	*36*	*100%*

[A] Staff assumption that costs would be apportioned by number of infrastructure projects for each vessel type. Applying the Proposed Regulation to all scenarios as an estimate.

Berth and Terminal Counts, Anticipated Infrastructure Needs, and Unique Vessel Counts

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CONTAINER/REEFER

Scenario	# Additional Unique Vessels that would Install SP due to New Regulation[A]	Year Begin Construction
Proposed Reg./Alternative 2	57	2020
Alternative 1	62	

	All Scenarios[B]						Proposed Regulation and Alternative 2[B]		
Port	# Terminals Subject to Terminal Threshold	# Berths Subject to Terminal Threshold	# Berth SP Retrofits Required for New Regulation[C]	# New Vaults Required for New Regulation[D]	# New Shoreside Cable Reels	Year Begin Construction	# Land-Based Capture & Control Systems	# Infrastructure Projects for Land-Based C&C	# Barge-Based Capture & Control Systems
Los Angeles	7	22	0	2	0	2020	0	0	0
Long Beach	6	20	0	0	0		0	0	1
Oakland	4	12	0	3	0		0	0	0
San Diego	1	3	0	0	0		0	0	0
Hueneme	1	3	0	0	0		0	0	0
Total:	*19*	*60*	*0*	*5*	*0*	*--*	*0*	*0*	*1*

[A] Assumptions:

<u>Proposed Regulation and Alternative 2</u>

1. Staff assumes that "Frequent vessels" to California that are not currently shore power-equipped will install shore power to meet the requirements of the existing At-Berth Regulation by 2020. A "frequent vessel" is defined as a vessel that visited any terminal in California four or more times in 2017, based on CSLC data.

2. "Infrequent vessels" that visited Port of Oakland one or more times in 2017 (CSLC data) will need to install shore power in response to the Proposed Regulation. Remaining vessels without shore power will need to use TIEs/VIEs.

3. "Infrequent vessels" that visited POLA or POLB three or more times in 2017 (CSLC data) will need to install shore power in response to the Proposed Regulation. Remaining vessels without shore power will need to use TIEs/VIEs or alternative emissions control.

Alternative 1

1. Same assumptions as above, except all vessels making 2+ visits in LA/LB will install shore power equipment.

[B] Terminal, berth, retrofit, vault, reel, and C&C system counts from Staff Berth Analysis

[C] "Berth Retrofit" means installing shore power on a berth where none currently exists.

[D] "New Vaults" means installing additional vaults on a berth where shore power already exists.

CRUISE

Scenario	# Additional Unique Vessels that would Install SP due to New Regulation[A]	Year Begin Construction
All	26	2020

	All Scenarios[B]					
Port	# Terminals Subject to Terminal Threshold	# Berths Subject to Terminal Threshold	# Berth SP Retrofits Required for New Regulation	# New Vaults Required for New Regulation	# New Shoreside Cable Reels	Year Begin Construc-tion
Los Angeles	1	2	0	0	0	2020
Long Beach	1	1	0	0	0	
San Francisco	1	2	1	0	0	
San Diego	2	6	0	0	0	
Total:	*5*	*11*	*1*	*0*	*0*	--

[A] Assumes that all vessels that visited California in 2017 (CSLC data) one or more times that do not currently have shore power would install it due to the new regulation.

[B] Terminal, berth, retrofit, vault and reel counts from Staff Berth Analysis.

RO-RO

Unique Vessel Count for Vessel Modifications, Proposed Regulation and Alternative 2[A]	0
Year Begin Construction, Proposed Regulation and Alternative 2	N/A
Unique Vessel Count for Vessel Modifications, Alternative 1[B]	261
Year Begin Construction	2024

	All Scenarios[C]			Alt. 1 Only	Proposed Regulation Only[C]		
Port/IMT	**# Terminals Subject to Terminal Threshold**	**# Berths Subject to Terminal Threshold**	**Year Begin Infra-structure Construc-tion**	**# Berth SP Retrofits Required for New Regulation**	**# Land-Based Capture & Control Systems**	**# Infra-structure Projects for Land-Based C&C**	**# Barge-Based Capture & Control Systems**
Los Angeles	1	4	2024	*4*	0	0	1
Long Beach	3	4		*4*	1	0	1
San Francisco	1	1		*1*	0	0	1
San Diego	1	5		*5*	1	0	1
Hueneme	3	4		*4*	1	0	0
Richmond Area	1	1		*1*	0	0	1
Carquinez Area	1	2		*2*	0	0	1
Total:	*11*	*21*	--	*21*	*3*	*0*	*6*

[A] Staff does not anticipate vessel-side infrastructure will be needed for use of land-side capture and control systems.

[B] Includes all Ro-Ro vessels that visited California in 2017 based on CSLC data.

[C] Terminal, berth, C&C system and infrastructure project counts from Staff Berth Analysis.

TANKERS

Unique Vessel Count for Vessel Modifications, Proposed Regulation and Alternative 2[A]	0
Year Begin Construction, Proposed Regulation and Alternative 2	N/A
Unique Vessel Count for Vessel Modifications, Alternative 1[B]	414
Year Begin Construction, Alternative 1	2026

TERMINAL THRESHOLD: 20

All Scenarios[C]	Alt. 1 Only	Prop. Reg. & Alt. 2

Port/IMT	# Terminals Subject to Terminal Threshold	# Berths Subject to Terminal Threshold	Year Begin Berth Infra-structure Construc-tion	# Berth SP Retrofits Required for New Regulation	# New Shoreside Cable Reels[D]	# Berth Infra-structure Projects for Land-Based C&C[E]
Long Beach	3	7	2024	*7*	0	7
Los Angeles [F]	5	6		*6*	0	6
Stockton Area	1	1	2026	*1*	0	1
Richmond Area	4	7		*7*	0	7
Carquinez Area	5	6		*6*	0	6
Rodeo Area	2	3		*3*	0	3
Total:	*20*	*30*	--	*30*	*0*	*30*

[A] Staff does not anticipate vessel-side infrastructure will be needed for use of land-side capture and control systems.

[B] Includes all tanker vessels that visited California in 2017 based on CSLC data.

[C] Terminal and berth counts from Staff Berth Analysis.

[D] No shoreside cable reels assumed because Staff assumes original infrastructure design will maximize shore power flexibility.

[E] Based on # of berths, since costs are estimated on a per-berth basis to account for scaled-up systems where more capacity is required.
Note that these do not match the total land-based systems identified in the Berth Analysis since this cost analysis applies a per-berth cost to these values.

[F] Excludes berths to be demolished (Kinder Morgan Berth 118 and Phillips 66 Berth 149) and accounts for one Shell berth at POLA (169).

Exceptions, TIEs, VIEs, and Remediation Fee Events

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THESE INPUTS APPLY TO THE PROPOSED REGULATION AND ALTERNATIVES 1 AND 2

PERCENT OF VISITS TO A TERMINAL CATEGORIZED AS A SAFETY/EMERGENCY EXCEPTION*

Vessel Type	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Container, Reefer	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%
Cruise	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%
Ro-Ro					0.62%	0.62%	0.62%	0.62%	0.62%	0.62%	0.62%
POLA/POLB Tankers							0.62%	0.62%	0.62%	0.62%	0.62%
All Other Tankers Statewide									0.62%	0.62%	0.62%

**Based on Staff analysis of Enforcement data for year 2017. In 2017, 21 out of 2,929 container/reefer vessel visits and 0 out of 495 cruise vessel visits were reported as safety exceptions.*

PERCENT OF VISITS TO A TERMINAL CATEGORIZED AS A COMMISSIONING EXCEPTION*

Vessel Type	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Container, Reefer	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Cruise	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Ro-Ro					3%	3%	3%	3%	3%	3%	3%
POLA/POLB Tankers							3%	3%	3%	3%	3%
All Other Tankers Statewide									3%	3%	3%

**Based on Staff analysis of Enforcement data for year 2017.*

PERCENT OF VISITS TO A TERMINAL ALLOWED AS TERMINAL INCIDENT EVENTS (TIE)*

Vessel Type	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Container, Reefer	5%	5%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Cruise	5%	5%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Ro-Ro					5%	3%	3%	3%	3%	3%	3%
POLA/POLB Tankers							5%	3%	3%	3%	3%
All Other Tankers Statewide									5%	3%	3%

**Proposed Regulation*

PERCENT OF VISITS TO A TERMINAL ALLOWED AS VESSEL INCIDENT EVENTS (VIE)*

Vessel Type	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Container, Reefer	5%	5%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Cruise	5%	5%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Ro-Ro					5%	3%	3%	3%	3%	3%	3%
POLA/POLB Tankers							5%	3%	3%	3%	3%
All Other Tankers Statewide									5%	3%	3%

**Proposed Regulation*

PERCENT OF VISITS TO A TERMINAL ALLOWED AS A REMEDIATION FEE - TERMINAL UPGRADES/CONSTRUCTION*

Vessel Type	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Container, Reefer	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
Cruise	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
Ro-Ro					0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
POLA/POLB Tankers							0.50%	0.50%	0.50%	0.50%	0.50%
All Other Tankers Statewide									0.50%	0.50%	0.50%

**Based on Staff analysis of Enforcement data for year 2017.*

In 2017, there were 17 instances of terminal or port construction preventing shore power connection, out of 3,424 vessel visits from vessels that were shore power equipped.

PERCENT OF VISITS TO A TERMINAL ALLOWED AS A REMEDIATION FEE - VESSEL CONTROL EQUIPMENT REPAIR*

Vessel Type	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Container, Reefer	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cruise	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ro-Ro					0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
POLA/POLB Tankers							0.17%	0.17%	0.17%	0.17%	0.17%
All Other Tankers Statewide									0.00%	0.00%	0.00%

**Based on Staff analysis of Enforcement data for year 2017.*

Staff expects that most incidents related to vessel-side equipment would use VIEs. Based on 2017 data, only one So. Cal. tanker visit would have been expected to use the remediation fee.

REMEDIATION FEE AMOUNTS

Vessel Type	**Vessel Hourly Fee***	**Terminal Hourly Fee***

Container/Reefer	$2,395	$2,395
Cruise	$12,879	$12,879
Ro-Ro	$1,515	$1,515
Product Tankers	$1,783	$1,783
Crude Tankers	$9,873	$9,873

**Based on Cost-Effectiveness of $100,000 per weighted ton of emissions*

Annual Vessel Visits

Formatting Legend
Original Input
Calculation

CONTAINER/REEFER

													Vessel Visit Count Applies to:				
													SP energy costs and fuel savings	SP energy costs and fuel savings	SP labor costs	SP labor costs	C&C visits
Port	A. All Annual Vessel Visits	B. Newly Regulated Annual Vessel Visits - Un-adjusted	C. *Prop. Reg. & Alt. 2* Annual Vessel Visits from Infrequent Vessels Not Antici-pated to Install Shore Power	D. *Alt. 1* Annual Vessel Visits from Infrequent Vessels Not Antici-pated to Install Shore Power	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commis-sioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remedi-ation Fee Visits - Terminal Issues	6. Visits Removed for Remedi-ation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. *Prop. Reg. & Alt. 2* Newly Regulated Annual Vessel Visits - Adjusted for non-SP vessels, all Exceptions, Commis-sioning TIEs, VIEs and Remedi-ation Fee Uses	10. *Alt. 1* Newly Regulated Annual Vessel Visits - Adjusted for non-SP vessels, all Exceptions, Commis-sioning TIEs, VIEs and Remedi-ation Fee Uses	11. *Prop. Reg. & Alt. 2* Newly Regulated Annual Vessel Visits - Adjusted for non-SP vessels, Exceptions, Commis-sioning, and Remedi-ation Fee Uses Only	12. *Alt. 1* Newly Regulated Annual Vessel Visits - Adjusted for non-SP vessels, Exceptions, Commis-sioning, and Remedi-ation Fee Uses Only	13. *Prop. Reg. & Alt. 2* Capture & Control Barge-Based Visits**
	All Years				Annual Vessel Visits for Years 2021 - 2022												
Los Angeles	1029	123	21	21	6	31	51	51	5	0	884	14%	0	0	60	60	21
Long Beach	909	89	34	24	6	27	45	45	5	0	781	14%	0	0	18	28	34
Oakland	1597	191	0	0	10	48	80	80	8	0	1372	14%	0	0	125	125	0
San Diego	52	0	0	0	0	2	3	3	0	0	45	14%	0	0	0	0	0
Hueneme	155	0	0	0	1	5	8	8	1	0	133	14%	0	0	0	0	0
Total:	3742	403	55	45	23	112	187	187	19	0	3214	14%	0	0	202	212	55

CONTAINER/REEFER

Vessel Visit Count Applies to:				
SP energy costs and fuel savings	SP energy costs and fuel savings	SP labor costs	SP labor costs	C&C visits

Port	A. All Annual Vessel Visits	B. Newly Regulated Annual Vessel Visits - Un-adjusted	C. *Prop. Reg. & Alt. 2* Annual Vessel Visits from Infrequent Vessels Not Antici-pated to Install Shore Power	D. *Alt. 1* Annual Vessel Visits from Infrequent Vessels Not Antici-pated to Install Shore Power	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commissioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remediation Fee Visits - Terminal Issues	6. Visits Removed for Remediation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. *Prop. Reg. & Alt. 2* Newly Regulated Annual Vessel Visits - Adjusted for non-SP vessels, all Exceptions, Commissioning TIEs, VIEs and Remediation Fee Uses	10. *Alt. 1* Newly Regulated Annual Vessel Visits - Adjusted for non-SP vessels, all Exceptions, Commissioning TIEs, VIEs and Remediation Fee Uses	11. *Prop. Reg. & Alt. 2* Newly Regulated Annual Vessel Visits - Adjusted for non-SP vessels, Exceptions, Commissioning, and Remediation Fee Uses Only	12. *Alt. 1* Newly Regulated Annual Vessel Visits - Adjusted for non-SP vessels, Exceptions, Commissioning, and Remediation Fee Uses Only	13. *Prop. Reg. & Alt. 2* Capture & Control Barge-Based Visits**
		All Years			Annual Vessel Visits for Years 2023 - 2032												
Los Angeles	1029	123	21	21	6	31	31	31	5	0	925	10%	0	0	60	60	21
Long Beach	909	89	34	24	6	27	27	27	5	0	817	10%	0	0	18	28	34
Oakland	1597	191	0	0	10	48	48	48	8	0	1435	10%	29	29	125	125	0
San Diego	52	0	0	0	0	2	2	2	0	0	47	10%	0	0	0	0	0
Hueneme	155	0	0	0	1	5	5	5	1	0	139	10%	0	0	0	0	0
Total:	3742	403	55	45	23	112	112	112	19	0	3363	10%	29	29	202	212	55

**TIEs and VIEs are calculated as a percent of the total vessel visits (all berths combined) for regulated vessel types to that terminal during the previous year (minimum one TIE and VIE)*

***Based on Berth Analysis, Staff does not anticipate land-based capture and control would be used at container/reefer terminals.*

Data Assumptions:

A. Includes all vessel visits controlled under the proposed Regulation, including those controlled under the existing At Berth Regulation. Values from Staff Berth Analysis.

B. Values from Staff Berth Analysis

C. Includes visits from vessels that do not currently have shore power and would not install it due to the new regulation because they do not meet the filters described in the "Berths, Terminals, Vessels" tab. Excludes visits from vessels that would be expected to install shore power due to the existing regulation. Values from Staff Berth Analysis.

D. Same values as Data Input C. except 10 fewer visits at POLB and 1 fewer visit at Port of Oakland would be conducted by vessels not expected to install shore power (vessel assumptions stated on "Berths, Terminals, Vessels" tab

Equations:

1. Input A. [#] x Exception Rate [%]
2. Input A. [#] x Exception Rate [%]
3. Input A. [#] x TIE Rate [%]
4. Input A. [#] x VIE Rate [%]
5. Input A. [#] x Remediation Fee Visit Rate - Terminal Issues [%]
6. Input A. [#] x Remediation Fee Visit Rate - Vessel Issues [%]
7. Input A. [#] - Sum of calculations 1. through 6. [#]
8. [Input A. [#] - Calculation 7.[#]] / [Input A. [#]]
9. Input B. [#] - Input C. [#] - Sum of calculations 1. through 6. [#] (Note if result is a negative # of vessel visits, then result is set equal to zero)
10. Input B. [#] - Input D. [#] - Sum of calculations 1. through 6. [#] (Note if result is a negative # of vessel visits, then result is set equal to zero)
11. Input B. [#] - Input C. [#] - Sum of calculations 1., 2., 5. and 6. [#] (Note if result is a negative # of vessel visits, then result is set to zero)
12. Input B. [#] - Input D. [#] - Sum of calculations 1., 2., 5. and 6. [#] (Note if result is a negative # of vessel visits, then result is set to zero)
13. For ports where Staff expects capture and control would be used (LA and LB), equals all of the Annual Vessel Visits from Infrequent Vessels not Anticipated to Install Shore Power. Staff assumes that TIEs and VIEs would be used at Ports of Oakland, San Diego and Hueneme.

CRUISE

												Vessel Visit Count Applies to:	
												SP energy costs and fuel savings	SP labor costs
	A. All Annual Vessel Visits	B. Newly Regulated Annual Vessel Visits - Un-adjusted	C. *All Scenarios* Annual Vessel Visits from Infrequent Vessels Not Antici-pated to Install Shore Power	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commis-sioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remedi-ation Fee Visits - Terminal Issues	6. Visits Removed for Remedi-ation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. *All Scenarios* Newly Regulated Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning TIEs, VIEs and Remedi-ation Fee Uses	10. *All Scenarios* Newly Regulated Annual Vessel Visits - Adjusted for Exceptions, Commis-sioning, and Remedi-ation Fee Uses Only
Port	All Years			Annual Numbers for Years 2021 - 2022									
Los Angeles	101	22	0	1	3	5	5	1	0	87	14%	8	18
Long Beach	256	0	0	2	8	13	13	1	0	220	14%	0	0
San Francisco	81	28	0	1	2	4	4	0	0	70	14%	17	25
San Diego	89	16	0	1	3	4	4	0	0	76	14%	3	12
Total:	527	66	0	3	16	26	26	3	0	453	14%	28	55

CRUISE

												Vessel Visit Count Applies to:	
												SP energy costs and fuel savings	SP labor costs
	A. All Annual Vessel Visits	B. Newly Regulated Annual Vessel Visits - Un-adjusted	C. *All Scenarios* Annual Vessel Visits from Infrequent Vessels Not Antici-pated to Install Shore Power	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commis-sioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remedi-ation Fee Visits - Terminal Issues	6. Visits Removed for Remedi-ation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. *All Scenarios* Newly Regulated Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning TIEs, VIEs and Remedi-ation Fee Uses	10. *All Scenarios* Newly Regulated Annual Vessel Visits - Adjusted for Exceptions, Commis-sioning, and Remedi-ation Fee Uses Only
Port	All Years			Annual Numbers for Years 2023 - 2032									

Los Angeles	101	22	0	1	3	3	3	1	0	91	10%	12	18
Long Beach	256	0	0	2	8	8	8	1	0	230	10%	0	0
San Francisco	81	28	0	1	2	2	2	0	0	73	10%	20	25
San Diego	89	16	0	1	3	3	3	0	0	80	10%	7	12
Total:	527	66	0	3	16	16	16	3	0	474	10%	39	55

**TIEs and VIEs are calculated as a percent of the total vessel visits (all berths combined) for regulated vessel types to that terminal during the previous year (minimum one TIE and VIE)*

Data Assumptions:

A. Includes all vessel visits controlled under the proposed Regulation, including those controlled under the existing At Berth Regulation. Values from Staff Berth Analysis.

B. Includes vessel visits from fleets that are unregulated under the existing At-Berth Regulation, plus additional vessel visits conducted by non-SP-capable vessels from currently regulated fleets, according to the filters described on the "Berths, Terminals, Vessels" tab. Values from Staff Berth

C. Staff anticipates all non-SP-capable cruise vessels would install shore power.

Equations:

1. Input A. [#] x Exception Rate [%]

2. Input A. [#] x Exception Rate [%]

3. Input A. [#] x TIE Rate [%]

4. Input A. [#] x VIE Rate [%]

5. Input A. [#] x Remediation Fee Visit Rate - Terminal Issues [%]

6. Input A. [#] x Remediation Fee Visit Rate - Vessel Issues [%]

7. Input A. [#] - Sum of calculations 1. through 6. [#]

8. [Input A. [#] - Calculation 7.[#]] / [Input A. [#]]

9. Input B. [#] - Sum of calculations 1. through 6. [#] (Note if result is a negative # of vessel visits, then result is set equal to zero)

RO-RO

										Vessel Visit Count Applies to:			
										C&C visits	C&C visits	SP energy costs and fuel savings	SP labor costs
	A. All Annual Vessel Visits	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commissioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remediation Fee Visits - Terminal Issues	6. Visits Removed for Remediation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. *Prop. Reg.* Capture & Control Barge-Based Visits	10. *Prop. Reg.* Capture & Control Land-Based Visits	11. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commissioning TIEs, VIEs and Remediation Fee Uses	12. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commissioning, and Remediation Fee Uses
Port/IMT	All Years	Annual Numbers for Year 2025											
Los Angeles	94	1	3	5	5	0	0	81	14%	90	0	81	90
Long Beach	211	1	6	11	11	1	0	181	14%	103	100	181	202
San Francisco	26	0	1	1	1	0	0	22	14%	25	0	22	25
San Diego	253	2	8	13	13	1	0	217	14%	196	47	217	243
Hueneme	240	1	7	12	12	1	0	206	14%	0	230	206	230
Richmond Area	71	0	2	4	4	0	0	61	14%	68	0	61	68
Carquinez Area	122	1	4	6	6	1	0	105	14%	117	0	105	117
Total:	1017	6	31	51	51	5	0	873	14%	599	377	873	975

RO-RO

										Vessel Visit Count Applies to:			
										C&C visits	C&C visits	SP energy costs and fuel savings	SP labor costs
	A. All Annual Vessel Visits	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commissioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remediation Fee Visits - Terminal Issues	6. Visits Removed for Remediation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. *Prop. Reg.* Capture & Control Barge-Based Visits	10. *Prop. Reg.* Capture & Control Land-Based Visits	11. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commissioning TIEs, VIEs and Remediation Fee Uses	12. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commissioning, and Remediation Fee Uses
Port/IMT	All Years	Annual Numbers for Years 2026 - 2032											
Los Angeles	94	1	3	3	3	0	0	84	10%	90	0	84	90
Long Beach	211	1	6	6	6	1	0	190	10%	103	100	190	202
San Francisco	26	0	1	1	1	0	0	23	10%	25	0	23	25
San Diego	253	2	8	8	8	1	0	227	10%	196	47	227	243
Hueneme	240	1	7	7	7	1	0	216	10%	0	230	216	230
Richmond Area	71	0	2	2	2	0	0	64	10%	68	0	64	68
Carquinez Area	122	1	4	4	4	1	0	110	10%	117	0	110	117
Total:	1017	6	31	31	31	5	0	914	10%	599	377	914	975

**TIEs and VIEs are calculated as a percent of the total vessel visits (all berths combined) for regulated vessel types to that terminal during the previous year (minimum one TIE and VIE)*

Data Assumptions:

A. Includes all vessel visits controlled under the proposed Regulation. Values from Staff Berth Analysis.

Equations:

1. Input A. [#] x Exception Rate [%]
2. Input A. [#] x Exception Rate [%]
3. Input A. [#] x TIE Rate [%]
4. Input A. [#] x VIE Rate [%]
5. Input A. [#] x Remediation Fee Visit Rate - Terminal Issues [%]
6. Input A. [#] x Remediation Fee Visit Rate - Vessel Issues [%]
7. Input A. [#] - Sum of calculations 1. through 6. [#]
8. [Input A.s [#] - Calculation 7.[#]] / [Input A. [#]]
9. For ports/IMTs where only barge-based C&C systems would be used, = Input A. [#]. For ports/IMTs where barge-based and land-based systems may be used, = Input A. [#] - [Sum of calculations 1., 2., 5. and 6./2] [#]
10. For ports/IMTs where only land-based C&C systems would be used, = Input A. [#]. For ports/IMTs where barge-based and land-based systems may be used, = Input A. [#] - [Sum of calculations 1., 2., 5. and 6./2] [#]
11. Equals calculation 7.
12. Input A. [#] - Sum of calculations 1., 2., 5. and 6. [#]

ALL TANKERS - POLA/POLB

Vessel Visit Count Applies to:		
C&C visits	SP energy costs and fuel savings	SP labor costs

Port	A. All Annual Vessel Visits	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commis-sioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remedi-ation Fee Visits - Terminal Issues	6. Visits Removed for Remedi-ation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. Prop.. Reg./Alt. 2 Capture & Control Land-Based Visits	10. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning TIEs, VIEs and Remedi-ation Fee Uses	11. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning, and Remedi-ation Fee Uses
	All Years	Annual Numbers for Year 2027										
Los Angeles	187	*1*	*6*	*9*	*9*	*1*	*0*	*160*	*14%*	*179*	*160*	*179*
Long Beach	359	*2*	*11*	*18*	*18*	*2*	*1*	*308*	*14%*	*344*	*308*	*344*
Total:	*546*	*3*	*16*	*27*	*27*	*3*	*1*	*468*	*14%*	*523*	*468*	*523*

ALL TANKERS - POLA/POLB

Vessel Visit Count Applies to:		
C&C visits	SP energy costs and fuel savings	SP labor costs

Port	A. All Annual Vessel Visits	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commis-sioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remedi-ation Fee Visits - Terminal Issues	6. Visits Removed for Remedi-ation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. Prop.. Reg./Alt. 2 Capture & Control Land-Based Visits	10. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning TIEs, VIEs and Remedi-ation Fee Uses	11. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning, and Remedi-ation Fee Uses
	All Years	Annual Numbers for Years 2028 - 2032										
Los Angeles	187	*1*	*6*	*6*	*6*	*1*	*0*	*168*	*10%*	*179*	*168*	*179*
Long Beach	359	*2*	*11*	*11*	*11*	*2*	*1*	*322*	*10%*	*344*	*322*	*344*
Total:	*546*	*3*	*16*	*16*	*16*	*3*	*1*	*490*	*10%*	*523*	*490*	*523*

**TIEs and VIEs are calculated as a percent of the total vessel visits (all berths combined) for regulated vessel types to that terminal during the previous year (minimum one TIE and VIE)*

Data Assumptions:
A. Includes all vessel visits controlled under the proposed Regulation. Values from Staff Berth Analysis.

Equations:
1. Input A. [#] x Exception Rate [%]
2. Input A. [#] x Exception Rate [%]
3. Input A. [#] x TIE Rate [%]
4. Input A. [#] x VIE Rate [%]
5. Input A. [#] x Remediation Fee Visit Rate - Terminal Issues [%]
6. Input A. [#] x Remediation Fee Visit Rate - Vessel Issues [%]

7. Input A. [#] - Sum of calculations 1. through 6. [#]
8. [Input A.s [#] - Calculation 7.[#]] / [Input A. [#]]
9. Equals Input A. [#] - Sum of calculations 1., 2., 5. and 6. [#]
10. Equals calculation 7.
11. Equals calculation 9.

ALL TANKERS - ALL OTHER STATEWIDE

										Vessel Visit Count Applies to:		
										C&C visits	SP energy costs and fuel savings	SP labor costs
	A. All Annual Vessel Visits	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commis-sioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remedi-ation Fee Visits - Terminal Issues	6. Visits Removed for Remedi-ation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. Prop. Reg./Alt. 2 Capture & Control Land-Based Visits	10. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning TIEs, VIEs and Remedi-ation Fee Uses	11. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning, and Remedi-ation Fee Uses
Port/IMT	All Years	Annual Numbers for Years 2029 - 2030										
Stockton Area**	34	0	1	2	2	0	0	29	14%	33	29	33
Richmond Area	391	2	12	20	20	2	0	336	14%	375	336	375
Carquinez Area	241	1	7	12	12	1	0	207	14%	231	207	231
Rodeo Area	108	1	3	5	5	1	0	93	14%	104	93	104
Total:	774	5	23	39	39	4	0	665	14%	742	665	742

ALL TANKERS - ALL OTHER STATEWIDE

										Vessel Visit Count Applies to:		
										C&C visits	SP energy costs and fuel savings	SP labor costs
	A. All Annual Vessel Visits	1. Visits Removed for Safety Exceptions	2. Visits Removed for Commis-sioning	3. Visits Removed for TIEs*	4. Visits Removed for VIEs*	5. Visits Removed for Remedi-ation Fee Visits - Terminal Issues	6. Visits Removed for Remedi-ation Fee Visits - Vessel Issues	7. All Annual Vessel Visits - Adjusted	8. Total Percent of Annual Visits Removed	9. Prop. Reg./Alt. 2 Capture & Control Land-Based Visits	10. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning TIEs, VIEs and Remedi-ation Fee Uses	11. *Alt. 1* All Annual Vessel Visits - Adjusted for all Exceptions, Commis-sioning, and Remedi-ation Fee Uses
Port/IMT	All Years	Annual Numbers for Years 2031 - 2032										
Stockton Area**	34	0	1	1	1	0	0	31	10%	33	31	33

Richmond Area	391	2	12	12	12	2	0	351	10%	375	351	375
Carquinez Area	241	1	7	7	7	1	0	217	10%	231	217	231
Rodeo Area	108	1	3	3	3	1	0	97	10%	104	97	104
Total:	774	5	23	23	23	4	0	696	10%	742	696	742

**TIEs and VIEs are calculated as a percent of the total vessel visits (all berths combined) for regulated vessel types to that terminal during the previous year (minimum one TIE and VIE)*

***Includes berths SCK 2-3, 7-8 and 9*

Data Assumptions:

A. Includes all vessel visits controlled under the proposed Regulation. Values from Staff Berth Analysis.

Equations:

1. Input A. [#] x Exception Rate [%]
2. Input A. [#] x Exception Rate [%]
3. Input A. [#] x TIE Rate [%]
4. Input A. [#] x VIE Rate [%]
5. Input A. [#] x Remediation Fee Visit Rate - Terminal Issues [%]
6. Input A. [#] x Remediation Fee Visit Rate - Vessel Issues [%]
7. Input A. [#] - Sum of calculations 1. through 6. [#]
8. [Input A.[#] - Calculation 7.[#]] / [Input A. [#]]
9. Equals Input A. [#] - Sum of calculations 1., 2., 5. and 6. [#]
10. Equals calculation 7.
11. Equals calculation 9.

Capture & Control Costs
Container/Reefer & Ro-Ro

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Calculation

INPUTS:

Barge-Based Capture and Control	**Unit**	**Value**
Hourly Fee - Container/Reefer, Ro-Ro	Cost per hour ($)	$900

Port/IMT	**Ro-Ro Land-Based C&C Capital Costs**	
	% of Costs Borne by Port	**% of Costs Borne by Terminal**
Los Angeles	0%	0%
Long Beach	100%	0%
Oakland	▨	▨
San Francisco	0%	0%
San Diego	0%	100%
Hueneme	100%	0%
Stockton Area	▨	▨
Richmond Area	0%	100%
Carquinez Area	0%	100%
Rodeo Area	▨	▨

Emission Control Time at Berth	**Unit**	**Value**
Container/Reefer	hours per visit	38.8
Ro-Ro	hours per visit	19.8

Land-Based Capture and Control	**Unit**	**Value**
Land-Based Emission Treatment System Cost - Ro-Ro Terminals	Cost per system ($)	$3,600,000
Labor Costs	Hourly cost per system ($)	$0
Annual Performance Testing	Cost per system ($)	$12,000
Cost to Obtain Initial CARB Technology Approval	Cost per approval ($)	$150,000
Annual Operating Costs	Cost per hour ($)	$100
CRF (5%, 20 years) for land-side equipment	fraction	0.0802
Annual Maintenance Costs	Annual cost per system ($)	$17,500

Scenario	**Land-Based Systems - Capital**	**Units/Basis**	**Ports Value**	**Year Begin Construc-tion**	**Terminals Value**
Proposed Reg.	Land-Based Emission Treatment Systems - Ro-Ro Vessels	# systems	1	2024	2

Annual Inputs	**Units**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer															
Annual C&C Vessel Visits - Container/Reefer	#	▨	▨	*55*	*55*	*55*	*55*	*55*	*55*	*55*	*55*	*55*	*55*	*55*	*55*
Container/Reefer Compounded Growth Factors	%	*3.9%*	*8.0%*	*15.3%*	*19.4%*	*23.8%*	*28.5%*	*33.4%*	*41.0%*	*44.4%*	*48.2%*	*52.3%*	*56.7%*	*61.4%*	*69.1%*
Ro-Ro															
Annual C&C Barge-Based Vessel Visits - Ro-Ro	#	▨	▨	▨	▨	▨	▨	*599*	*599*	*599*	*599*	*599*	*599*	*599*	*599*
Annual C&C Land-Based Vessel Visits - Ro-Ro	#	▨	▨	▨	▨	▨	▨	*377*	*377*	*377*	*377*	*377*	*377*	*377*	*377*
Ro-Ro Compounded Growth Factors	%	*3.7%*	*7.5%*	*11.5%*	*15.1%*	*18.4%*	*21.9%*	*25.4%*	*29.1%*	*32.9%*	*35.9%*	*39.0%*	*42.2%*	*45.4%*	*48.9%*

CALCULATIONS:

Barge-Based Capture & Control Costs (All Adjusted for Annual Growth) Proposed Regulation/Alternative 2*	**Cost Incurred by**	**Vessel Type**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**

1. Hourly Costs	Vessel Operator	Container/ Reefer			*$2,211,022*	*$2,290,229*	*$2,374,660*	*$2,464,421*	*$2,559,643*	*$2,704,984*	*$2,771,038*	*$2,843,326*	*$2,921,700*	*$3,006,076*	*$3,096,425*	*$3,244,398*
2. Hourly Costs	Vessel Operator	Ro-Ro							*$13,380,817*	*$13,773,112*	*$14,177,231*	*$14,499,556*	*$14,829,245*	*$15,166,465*	*$15,511,391*	*$15,878,063*

**Ro-Ro vessels are excluded from emission control requirements under Alternative 2.*

Equations

1. Annual C&C Barge-Based Vessel Visits [#] x Emission Control Duration per Visit [hr] x Hourly Fee [$/hr] x [1 + Compounded Growth Factor [fraction]]
2. Annual C&C Barge-Based Vessel Visits [#] x Emission Control Duration per Visit [hr] x Hourly Fee [$/hr] x [1 + Compounded Growth Factor [fraction]]

Land-Based Capture & Control Costs (All Adjusted for Annual Growth) Proposed Regulation/Alternative 2*	**Cost Incurred by**	**Vessel Type**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
1. Annualized Capital Costs- Emission Treatment Systems	Ports	Ro-Ro						*$351,914*	*$362,193*	*$372,812*	*$383,751*	*$392,475*	*$401,399*	*$410,527*	*$419,864*	*$429,789*
1. Annualized Capital Costs- Emission Treatment Systems	Terminals	Ro-Ro						*$703,828*	*$724,387*	*$745,624*	*$767,501*	*$784,951*	*$802,799*	*$821,055*	*$839,728*	*$859,578*
2. Performance Testing	Terminals	Ro-Ro							*$15,054*	*$15,495*	*$15,950*	*$16,312*	*$16,683*	*$17,063*	*$17,451*	*$17,863*
3. Labor Costs	Terminals	Ro-Ro							*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
4. Maintenance Costs	Terminals	Ro-Ro							*$21,953*	*$22,597*	*$23,260*	*$23,789*	*$24,330*	*$24,883*	*$25,449*	*$26,051*
5. Operational Costs	Terminals	Ro-Ro							*$935,351*	*$962,773*	*$991,022*	*$1,013,554*	*$1,036,600*	*$1,060,172*	*$1,084,283*	*$1,109,914*

**Ro-Ro vessels are excluded from emission control requirements under Alternative 2.*

Equations

1. Land-Based Emission Treatment Systems [#] x Land-Based Emission Treatment System Cost [$] x [1 + Compounded Growth Factor [fraction]] x CRF [fraction]
2. Land-Based Emission Treatment Systems [#] x Annual Performance Testing Cost per System [$] x [1 + Compounded Growth Factor [fraction]
3. Annual Vessel Visits [#] x Emission Control Duration per Visit [hr] x [1 + Compounded Growth Factor [%]] x Hourly Labor Cost per System [$]
4. Land-Based Emission Treatment Systems [#] x Annual Maintenance Cost per System [$] x [1 + Compounded Growth Factor [fraction]
5. Annual Vessel Visits [#] x Emission Control Duration per Visit [hr] x Hourly Operating Costs [$/hr] x [1 + Compounded Growth Factor [fraction]]

SUBTOTALS:

Costs (All Adjusted for Annual Growth) Proposed Regulation	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Total Barge-Based Capture and Control Costs	*$0*	*$0*	*$2,211,022*	*$2,290,229*	*$2,374,660*	*$2,464,421*	*$15,940,460*	*$16,478,096*	*$16,948,269*	*$17,342,883*	*$17,750,945*	*$18,172,541*	*$18,607,815*	*$19,122,460*
Total Land-Based Capture and Control Costs	*$0*	*$0*	*$0*	*$0*	*$0*	*$1,759,569*	*$2,783,325*	*$2,864,925*	*$2,948,986*	*$3,016,032*	*$3,084,610*	*$3,154,755*	*$3,226,502*	*$3,302,773*
Total:	*$0*	*$0*	*$2,211,022*	*$2,290,229*	*$2,374,660*	*$4,223,990*	*$18,723,785*	*$19,343,022*	*$19,897,254*	*$20,358,915*	*$20,835,555*	*$21,327,296*	*$21,834,318*	*$22,425,233*

Costs (All Adjusted for Annual Growth) Alternative 2	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Total Barge-Based Capture and Control Costs	*$0*	*$0*	*$2,211,022*	*$2,290,229*	*$2,374,660*	*$2,464,421*	*$2,559,643*	*$2,704,984*	*$2,771,038*	*$2,843,326*	*$2,921,700*	*$3,006,076*	*$3,096,425*	*$3,244,398*
Total Land-Based Capture and Control Costs														
Total:	*$0*	*$0*	*$2,211,022*	*$2,290,229*	*$2,374,660*	*$2,464,421*	*$2,559,643*	*$2,704,984*	*$2,771,038*	*$2,843,326*	*$2,921,700*	*$3,006,076*	*$3,096,425*	*$3,244,398*

Costs by Vessel Type - Proposed Regulation and Alternative 2*	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	*$0*	*$0*	*$2,211,022*	*$2,290,229*	*$2,374,660*	*$2,464,421*	*$2,559,643*	*$2,704,984*	*$2,771,038*	*$2,843,326*	*$2,921,700*	*$3,006,076*	*$3,096,425*	*$3,244,398*
Ro-Ro	*$0*	*$0*	*$0*	*$0*	*$0*	*$1,055,741*	*$15,439,755*	*$15,892,414*	*$16,358,715*	*$16,730,637*	*$17,111,056*	*$17,500,165*	*$17,898,165*	*$18,321,258*
Total:	*$0*	*$0*	*$2,211,022*	*$2,290,229*	*$2,374,660*	*$3,520,162*	*$17,999,398*	*$18,597,398*	*$19,129,753*	*$19,573,964*	*$20,032,756*	*$20,506,241*	*$20,994,590*	*$21,565,655*

**Ro-Ro vessels are excluded from emission control requirements under Alternative 2.*

Capture & Control Costs

Tankers

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Calculation

INPUTS:

Emission Control Time at Berth	Unit	Value
Tankers (Average)	hours per visit	40.7

Land-Based Capture and Control	Unit	Value - POLA/ POLB	Value - Other Statewide
Land-Based Emission Control System Cost	Cost per berth ($)	$6,517,857	$6,517,857
Terminal Infrastructure (Emission Control System connections, electrical, foundation, etc.)	Cost per berth ($)	$7,000,000	$7,000,000
Emission Control System Support Structure	Cost per berth ($)	$5,000,000	$15,000,000
Terminal Infrastructure (Berth to Emission Control System Piping) Cost	Cost per berth ($)	$4,500,000	$4,500,000
Crane Cost	Cost per berth ($)	$7,000,000	$14,000,000
Total Cost of Crane Support Structures	Cost per berth ($)	$10,000,000	$20,000,000
Electric Utility Infrastructure Cost	Cost per berth ($)	$0	$0
Labor Costs	Annual cost per berth ($)	$1,000,000	$1,000,000
Annual Maintenance Costs	Annual cost per berth ($)	$162,867	$232,145
Annual Operating Costs	Hourly cost per visit ($)	$200	$500
Demurrage Costs	Total cost per visit ($)	$0	$0

Land-Based Capture and Control - All Systems	Unit	Value
Annual Performance Testing	Cost per berth ($)	$12,000
CRF (5%, 20 years) for land-side equipment	fraction	0.0802

Feasibility, Engineering and Permitting Costs for Tanker Terminal Capture and Control Projects - POLA/POLB	Value	Unit	Start Year
Feasibility Study Cost	$500,000	per berth	2020
Engineering Costs	$5,642,143	per berth	2020
Permitting Costs	$1,880,714	per berth	2020
Number of Studies	13		

Feasibility, Engineering and Permitting Costs for Tanker Terminal Capture and Control Projects - All Other Statewide	Value	Unit	Start Year
Feasibility Study Cost	$500,000	per berth	2022
Engineering Costs	$8,042,143	per berth	2022
Permitting Costs	$2,680,714	per berth	2022
Number of Studies	17		

Land-Based Systems - Capital/Construction	Units/Basis	Value	Start Year
POLA/POLB Tanker Terminals	# berths	13	2024
All Other Tanker Terminals Statewide	# berths	17	2026

POLA Berths	POLB Berths
6	7

Annual Inputs	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Tankers															
Annual C&C Land-Based Vessel Visits - POLA/POLB Tankers	#									*523*	*523*	*523*	*523*	*523*	*523*
Annual C&C Land-Based Vessel Visits - All Other Tankers Statewide	#											*742*	*742*	*742*	*742*
Tankers Compounded Growth Factors	%	*1.0%*	*1.5%*	*2.7%*	*3.5%*	*4.3%*	*5.1%*	*5.9%*	*7.1%*	*8.2%*	*9.4%*	*10.5%*	*11.7%*	*13.0%*	*14.3%*

CALCULATIONS:

Land-Based Capture & Control Costs (All Adjusted for Annual Growth) POLA/POLB Tanker Terminals	Equation Number	Cost Incurred by	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032

Emission Control Systems	1	Terminals						$7,142,180	$7,199,018	$7,277,916	$7,354,921	$7,433,059	$7,512,356	$7,592,835	$7,681,474	$7,768,890
Terminal Infrastructure (Emission Control System connections, electrical, foundation, etc.)	1	Ports						$7,670,505	$7,731,548	$7,816,283	$7,898,984	$7,982,902	$8,068,064	$8,154,496	$8,249,693	$8,343,575
Emission Control System Support Structure	1	Ports						$5,478,932	$5,522,534	$5,583,059	$5,642,131	$5,702,073	$5,762,903	$5,824,640	$5,892,638	$5,959,696
Berth-to-Emission Control System Piping	1	Ports						$4,931,039	$4,970,281	$5,024,753	$5,077,918	$5,131,866	$5,186,613	$5,242,176	$5,303,374	$5,363,727
Cranes	1	Ports						$7,670,505	$7,731,548	$7,816,283	$7,898,984	$7,982,902	$8,068,064	$8,154,496	$8,249,693	$8,343,575
Crane Support Structures	1	Ports						$10,957,865	$11,045,068	$11,166,118	$11,284,262	$11,404,146	$11,525,806	$11,649,280	$11,785,276	$11,919,393
Electric Utility Infrastructure Costs	1	Ports						$0	$0	$0	$0	$0	$0	$0	$0	$0
Labor Costs	2	Terminals									$7,576,236	$7,656,726	$7,738,408	$7,821,309	$7,912,616	$8,002,662
Labor Costs	2	Ports									$6,493,917	$6,562,908	$6,632,921	$6,703,979	$6,782,242	$6,859,424
Maintenance Costs	3	Terminals									$1,233,917	$1,247,026	$1,260,330	$1,273,831	$1,288,702	$1,303,368
Maintenance Costs	3	Ports									$1,057,643	$1,068,880	$1,080,283	$1,091,856	$1,104,602	$1,117,172
Operating Costs	4	Terminals									$4,603,782	$4,652,693	$4,702,328	$4,752,703	$4,808,187	$4,862,905
Feasibility Study Costs	5	Ports		$928,571	$928,571	$928,571	$928,571	$928,571	$928,571	$928,571						
Engineering Costs	5	Ports		$10,478,266	$10,478,266	$10,478,266	$10,478,266	$10,478,266	$10,478,266	$10,478,266						
Permitting Costs	5	Ports		$3,492,755	$3,492,755	$3,492,755	$3,492,755	$3,492,755	$3,492,755	$3,492,755						
Performance Testing	6	Terminals									$168,842	$170,636	$172,456	$174,303	$176,338	$178,345

Land-Based Capture & Control Costs (All Adjusted for Annual Growth) All Other Tanker Terminals Statewide	**Equation Number**	**Cost Incurred by**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Emission Control Systems	1	Terminals								$9,517,275	$9,617,974	$9,720,155	$9,823,850	$9,929,091	$10,045,005	$10,159,318
Terminal Infrastructure (Emission Control System connections, electrical, foundation, etc.)	1	Terminals								$10,221,293	$10,329,440	$10,439,180	$10,550,545	$10,663,572	$10,788,060	$10,910,829
Emission Control System Support Structure	1	Terminals								$21,902,770	$22,134,515	$22,369,671	$22,608,312	$22,850,511	$23,117,272	$23,380,348
Berth-to-Emission Control System Piping	1	Terminals								$6,570,831	$6,640,354	$6,710,901	$6,782,494	$6,855,153	$6,935,182	$7,014,104
Cranes	1	Terminals								$20,442,586	$20,658,880	$20,878,360	$21,101,091	$21,327,144	$21,576,121	$21,821,658
Crane Support Structures	1	Terminals								$29,203,694	$29,512,686	$29,826,228	$30,144,416	$30,467,349	$30,823,029	$31,173,797
Electric Utility Infrastructure Costs	1	Terminals								$0	$0	$0	$0	$0	$0	$0
Labor Costs	2	Terminals											$18,793,277	$18,994,606	$19,216,352	$19,435,036
Maintenance Costs	3	Terminals											$4,362,774	$4,409,512	$4,460,989	$4,511,756
Operating Costs	4	Terminals											$16,695,022	$16,873,873	$17,070,861	$17,265,129
Feasibility Study Costs	5	Terminals				$1,214,286	$1,214,286	$1,214,286	$1,214,286	$1,214,286	$1,214,286	$1,214,286				
Engineering Costs	5	Terminals				$19,530,918	$19,530,918	$19,530,918	$19,530,918	$19,530,918	$19,530,918	$19,530,918				
Permitting Costs	5	Terminals				$6,510,306	$6,510,306	$6,510,306	$6,510,306	$6,510,306	$6,510,306	$6,510,306				
Performance Testing	6	Terminals											$225,519	$227,935	$230,596	$233,220

**Ro-Ro vessels are not subject to emission control requirements under Alternative 2.*

Equations

1. Number of Berths with Land-Based Emission Treatment Systems [#] x Component Cost per Berth [$] x [1 + Compounded Growth Factor [fraction]] x CRF [fraction]
2. Number of Berths with Land-Based Emission Treatment Systems [#] x Annual Labor Cost Per Berth [$] x [1 + Compounded Growth Factor [fraction]]
3. Number of Berths with Land-Based Emission Treatment Systems [#] x Annual Maintenance Cost per Berth [$] x [1 + Compounded Growth Factor [fraction]]
4. Annual Vessel Visits [#] x Emission Control Duration per Visit [hr] x Hourly Operating Costs [$/hr] x [1 + Compounded Growth Factor [fraction]]
5. Cost per Berth [$] x Number of Berths [#] /7 years
6. Land-Based Emission Treatment Systems [#] x Annual Performance Testing Cost per System [$] x [1 + Compounded Growth Factor [fraction]]
7. Annual Vessel Visits [#] x Demurrage Cost per Visit [$] x [1 + Compounded Growth Factor [fraction]]

SUBTOTALS:

Costs (All Adjusted for Annual Growth) Proposed Regulation	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Total Land-Based Capture and Control Costs	$0	$14,899,592	$14,899,592	$42,155,102	$42,155,102	$86,006,128	$86,355,099	$184,697,964	$192,440,896	$194,195,820	$208,797,831	$211,034,653	$213,498,305	$215,927,927
Total Land-Based Capture and Control Costs	$0	$14,899,592	$14,899,592	$42,155,102	$42,155,102	$86,006,128	$86,355,099	$184,697,964	$192,440,896	$194,195,820	$208,797,831	$211,034,653	$213,498,305	$215,927,927

Costs (All Adjusted for Annual Growth) Alternative 2	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Total Land-Based Capture and Control Costs	$0	$14,899,592	$14,899,592	$42,155,102	$42,155,102	$86,006,128	$86,355,099	$184,697,964	$192,440,896	$194,195,820	$208,797,831	$211,034,653	$213,498,305	$215,927,927
Total:	$0	$14,899,592	$14,899,592	$42,155,102	$42,155,102	$86,006,128	$86,355,099	$184,697,964	$192,440,896	$194,195,820	$208,797,831	$211,034,653	$213,498,305	$215,927,927

Costs by Vessel Type - Proposed Regulation and Alternative 2*	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
POLA/POLB Tankers	*$0*	*$14,899,592*	*$14,899,592*	*$14,899,592*	*$14,899,592*	*$58,750,618*	*$59,099,589*	*$59,584,005*	*$66,291,537*	*$66,995,816*	*$67,710,531*	*$68,435,905*	*$69,234,836*	*$70,022,733*
All Other Tankers Statewide	*$0*	*$0*	*$0*	*$27,255,510*	*$27,255,510*	*$27,255,510*	*$27,255,510*	*$125,113,959*	*$126,149,359*	*$127,200,004*	*$141,087,299*	*$142,598,748*	*$144,263,468*	*$145,905,194*
Total:	*$0*	*$14,899,592*	*$14,899,592*	*$42,155,102*	*$42,155,102*	*$86,006,128*	*$86,355,099*	*$184,697,964*	*$192,440,896*	*$194,195,820*	*$208,797,831*	*$211,034,653*	*$213,498,305*	*$215,927,927*

**Under Alternative 2, no costs are incurred for Ro-Ro.*

Shore Power Berth Retrofit Costs

Formatting Legend
Value linked from another cell or tab
Calculation

INPUTS:

Fixed Inputs	Units	Value
Shore Power Retrofit Cost per Berth - Container/Reefer Berths	Cost per berth upgrade ($)	$7,010,813
Shore Power Cost for Additional Vault - Container/Reefer Berths	Cost per new vault ($)	$1,993,255
Shore Power Retrofit Cost per Berth - Cruise Berths	Cost per berth upgrade ($)	$83,200,000
Shore Power Retrofit Cost per Berth - Tanker Berths	Cost per berth upgrade ($)	$31,983,333
Shore Power Infrastructure Repair Costs after 20 Years	percent	50%
CRF (5%, 10 years) for berths	fraction	0.0802
Terminal Cable Reel Capital Costs	Cost per reel ($)	$250,000
Shore Power Terminal Equipment Maintenance Costs - Container/Reefer	Annual Cost per berth upgrade ($)	$24,285
Shore Power Terminal Equipment Maintenance Costs - Cruise	Annual Cost per berth upgrade ($)	$50,000

Alternative 1 - Tanker Terminal Costs			
Cost	POLA/ POLB	Other	Unit
Feasibility	$500,000	$500,000	cost per berth retrofit
Engineering	$3,838,000	$3,838,000	cost per berth retrofit
Permitting	$1,279,333	$1,279,333	cost per berth retrofit

Cost Apportionment	Proposed Regulation & Alternative 2			
	Shore Power Capital Costs		Shore Power Maintenance Costs	
Port/IMT	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal
Los Angeles	100%	0%	100%	0%
Long Beach	100%	0%	0%	100%
Oakland	100%	0%	100%	0%
San Francisco	100%	0%	100%	0%
San Diego	100%	0%	100%	0%
Hueneme	100%	0%	100%	0%
Stockton Area				
Richmond Area				
Carquinez Area				
Rodeo Area				

Cost Apportionment	Alternative 1			
	Shore Power Capital Costs		Shore Power Maintenance Costs	
Port/IMT	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal
Los Angeles	100%	0%	100%	0%
Long Beach	100%	0%	0%	100%
Oakland	100%	0%	100%	0%
San Francisco	100%	0%	100%	0%
San Diego	100%	0%	100%	0%
Hueneme	100%	0%	100%	0%
Stockton Area	0%	100%	0%	100%
Richmond Area	0%	100%	0%	100%
Carquinez Area	0%	100%	0%	100%
Rodeo Area	0%	100%	0%	100%

Shore Power Infrastructure by Port/IMT - ALL SCENARIOS	Berth Retrofits	Shore Power Vaults	Terminal Cable Reels
Container/Reefer			
Year Construction Starts	2020	2020	2020
Year Maintenance Starts	2021	2021	n/a
Port/IMT:			
Los Angeles	0	2	0
Long Beach	0	0	0
Oakland	0	3	0
San Diego	0	0	0
Hueneme	0	0	0
Total:	*0*	*5*	*0*
Cruise			
Year Construction Starts	2020	2020	2020
Year Maintenance Starts	2021	2021	n/a
Port/IMT:			
Los Angeles	0	0	0
Long Beach	0	0	0
San Francisco	1	0	0
San Diego	0	0	0
Total:	*1*	*0*	*0*

Shore Power Infrastructure by Port/Area IMTs - ALT. 1	Berth Retrofits - Ro-Ro	Berth Retrofits - POLA/POLB Tanker Terminals	Berth Retrofits - All Other Tanker Terminals
Year Construction Starts			
Year Maintenance Starts			
Port/IMT:			
Los Angeles			
Long Beach			
San Francisco			
San Diego			
Stockton Area			
Hueneme			
Richmond Area			
Carquinez Area			
Rodeo Area			
Total:	*19*	*13*	*17*

Annual Growth Factors	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Compound Growth Factor - Container/Reefer	%														
Compound Growth Factor - Cruise	%														
Compound Growth Factor - Ro-Ro	%														
Compound Growth Factor - Tankers	%														

CALCULATIONS:

Costs (All Adjusted for Annual Growth) All Scenarios for Container/Reefer and Cruise Vessels	Cost Incurred by	Vessel Type	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. SP Berth Retrofit Capital Costs	Ports	Container/Reefer		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
		Cruise		*$7,737,690*	*$8,022,491*	*$8,317,775*	*$8,623,927*	*$8,941,348*	*$9,270,453*	*$9,611,670*	*$9,965,447*	*$10,332,245*	*$10,712,544*	*$11,106,841*	*$11,515,650*	*$11,939,507*
2. SP Berth Retrofit Capital Costs	Terminals	Container/Reefer		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
		Cruise		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
3. SP Berth Retrofit Maintenance Costs	Ports	Container/Reefer			*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
		Cruise			*$60,115*	*$62,327*	*$64,622*	*$67,000*	*$69,466*	*$72,023*	*$74,674*	*$77,422*	*$80,272*	*$83,227*	*$86,290*	*$89,466*
4. SP Berth Retrofit Maintenance Costs	Terminals	Container/Reefer			*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
		Cruise			*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
5. Additional SP Vault Costs	Ports	Container/Reefer		*$921,238*	*$954,239*	*$989,418*	*$1,026,818*	*$1,066,493*	*$1,127,050*	*$1,154,572*	*$1,184,691*	*$1,217,346*	*$1,252,502*	*$1,290,147*	*$1,351,801*	*$1,416,412*
		Cruise		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
6. Additional SP Vault Costs	Terminals	Container/Reefer		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
		Cruise		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
7. Terminal Cable Reel Costs	Terminals	Container/Reefer		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
		Cruise		*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*

Costs (All Adjusted for Annual Growth) Alternative 1 for Ro-Ro and Tanker Vessels	Cost Incurred by	Vessel Type	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
1. SP Berth Retrofit Capital Costs	Ports	Ro-Ro						*$12,696,348*	*$13,068,576*	*$13,452,023*	*$13,757,860*	*$14,070,684*	*$14,390,655*	*$14,717,936*	*$15,065,852*	*$15,411,949*
		POLA/POLB Tankers						*$35,046,903*	*$35,325,810*	*$35,712,968*	*$36,090,832*	*$36,474,260*	*$36,863,369*	*$37,258,281*	*$37,693,240*	*$38,122,191*
		All Other Tankers								*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
2. SP Berth Retrofit Capital Costs	Terminals	Ro-Ro						*$705,353*	*$726,032*	*$747,335*	*$764,326*	*$781,705*	*$799,481*	*$817,663*	*$836,992*	*$856,219*
		POLA/POLB Tankers						*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
		All Other Tankers								*$46,701,573*	*$47,195,703*	*$47,697,109*	*$48,205,944*	*$48,722,368*	*$49,291,161*	*$49,852,097*
		Ro-Ro							*$439,015*	*$451,896*	*$462,170*	*$472,679*	*$483,428*	*$494,422*	*$506,110*	*$517,736*

3. SP Berth Retrofit Maintenance Costs	Ports	POLA/POLB Tankers									*$341,694*	*$345,324*	*$349,008*	*$352,747*	*$356,865*	*$360,926*
		All Other Tankers											*$0*	*$0*	*$0*	*$0*
4. SP Berth Retrofit Maintenance Costs	Terminals	Ro-Ro							*$156,791*	*$161,391*	*$165,061*	*$168,814*	*$172,653*	*$176,579*	*$180,753*	*$184,906*
		POLA/POLB Tankers									*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
		All Other Tankers											*$456,395*	*$461,284*	*$466,669*	*$471,980*
8. Feasibility	Ports	POLA/POLB Tankers		$928,571	$928,571	$928,571	$928,571	$928,571	$928,571	$928,571						
8. Engineering				$7,127,714	$7,127,714	$7,127,714	$7,127,714	$7,127,714	$7,127,714	$7,127,714						
8. Permitting				$2,375,905	$2,375,905	$2,375,905	$2,375,905	$2,375,905	$2,375,905	$2,375,905						
8. Feasibility	Terminals	All Other Tankers				$1,214,286	$1,214,286	$1,214,286	$1,214,286	$1,214,286	$1,214,286	$1,214,286				
8. Engineering						$9,320,857	$9,320,857	$9,320,857	$9,320,857	$9,320,857	$9,320,857	$9,320,857				
8. Permitting						$3,106,952	$3,106,952	$3,106,952	$3,106,952	$3,106,952	$3,106,952	$3,106,952				

<u>Equations:</u>

1. Σ [SP Berth Retrofits [#],port x % capital cost incurred by port [%],port] x Capital Cost per Berth Retrofit [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]
After 20 years, cost is multiplied by factor of 50 percent to account for repairs and replacement of parts (only relevant if costs are calculated past 2039)
2. Σ [SP Berth Retrofits [#],port x % capital cost incurred by terminal [%],port] x Capital Cost per Berth Retrofit [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]
After 20 years, cost is multiplied by factor of 50 percent to account for repairs and replacement of parts (only relevant if costs are calculated past 2039)
3. Σ [SP Berth Retrofits [#],port x % maintenance cost incurred by port [%],port] x Capital Cost per Berth Retrofit [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]
4. Σ [SP Berth Retrofits [#],port x % maintenance cost incurred by terminal [%],port] x Capital Cost per Berth Retrofit [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]
5. Σ [SP Vaults [#],port x % capital cost incurred by port [%],port] x Capital Cost per SP Vault [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]
6. Σ [SP Vaults [#],port x % capital cost incurred by terminal [%],port] x Capital Cost per SP Vault [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]
7. Σ [Terminal Cable Reels [#],port x % capital cost incurred by terminal [%],port] x Capital Cost per Terminal Cable Reel [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]
8. Cost per Berth [$] x Number of Berths [#] /7 years

SUBTOTALS:

Costs (All Adjusted for Annual Growth) Proposed Regulation	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
SP Berth Retrofit, New Vaults, and Cable Reel Capital Costs	*$0*	*$8,658,928*	*$8,976,731*	*$9,307,194*	*$9,650,745*	*$10,007,841*	*$10,397,503*	*$10,766,242*	*$11,150,138*	*$11,549,591*	*$11,965,046*	*$12,396,987*	*$12,867,451*	*$13,355,919*
SP Berth Retrofit Maintenance Costs	*$0*	*$0*	*$60,115*	*$62,327*	*$64,622*	*$67,000*	*$69,466*	*$72,023*	*$74,674*	*$77,422*	*$80,272*	*$83,227*	*$86,290*	*$89,466*
Total:	*$0*	*$8,658,928*	*$9,036,846*	*$9,369,521*	*$9,715,367*	*$10,074,841*	*$10,466,969*	*$10,838,265*	*$11,224,812*	*$11,627,014*	*$12,045,318*	*$12,480,214*	*$12,953,741*	*$13,445,385*

Costs by Vessel Type - Proposed Regulation and Alternative 2*	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	*$0*	*$921,238*	*$954,239*	*$989,418*	*$1,026,818*	*$1,066,493*	*$1,127,050*	*$1,154,572*	*$1,184,691*	*$1,217,346*	*$1,252,502*	*$1,290,147*	*$1,351,801*	*$1,416,412*
Cruise	*$0*	*$7,737,690*	*$8,082,606*	*$8,380,103*	*$8,688,549*	*$9,008,348*	*$9,339,919*	*$9,683,693*	*$10,040,121*	*$10,409,668*	*$10,792,816*	*$11,190,067*	*$11,601,940*	*$12,028,973*
Total:	*$0*	*$8,658,928*	*$9,036,846*	*$9,369,521*	*$9,715,367*	*$10,074,841*	*$10,466,969*	*$10,838,265*	*$11,224,812*	*$11,627,014*	*$12,045,318*	*$12,480,214*	*$12,953,741*	*$13,445,385*

**Under Alternative 2, no costs are incurred for Ro-Ro. Under both the Proposed Regulation and Alternative 2, Ro-Ro and Tanker berths are not expected to install shore power.*

Costs (All Adjusted for Annual Growth) Alternative 1	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
SP Berth Retrofit, New Vaults, and Cable Reel Capital Costs	*$0*	*$8,658,928*	*$8,976,731*	*$9,307,194*	*$9,650,745*	*$58,456,445*	*$59,517,920*	*$107,380,140*	*$108,958,859*	*$110,573,349*	*$112,224,495*	*$113,913,236*	*$115,754,695*	*$117,598,375*
SP Berth Retrofit Maintenance Costs	*$0*	*$0*	*$60,115*	*$62,327*	*$64,622*	*$67,000*	*$665,272*	*$685,310*	*$1,043,598*	*$1,064,239*	*$1,541,755*	*$1,568,259*	*$1,596,687*	*$1,625,014*
SP Feasibility, Engineering and Permitting Costs	*$0*	*$10,432,190*	*$10,432,190*	*$24,074,285*	*$24,074,285*	*$24,074,285*	*$24,074,285*	*$24,074,285*	*$13,642,095*	*$13,642,095*	*$0*	*$0*	*$0*	*$0*
Total:	*$0*	*$19,091,118*	*$19,469,036*	*$33,443,807*	*$33,789,652*	*$82,597,731*	*$84,257,478*	*$132,139,736*	*$123,644,553*	*$125,279,683*	*$113,766,250*	*$115,481,494*	*$117,351,382*	*$119,223,388*

Costs by Vessel Type - Alternative 1	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	*$0*	*$921,238*	*$954,239*	*$989,418*	*$1,026,818*	*$1,066,493*	*$1,127,050*	*$1,154,572*	*$1,184,691*	*$1,217,346*	*$1,252,502*	*$1,290,147*	*$1,351,801*	*$1,416,412*
Cruise	*$0*	*$7,737,690*	*$8,082,606*	*$8,380,103*	*$8,688,549*	*$9,008,348*	*$9,339,919*	*$9,683,693*	*$10,040,121*	*$10,409,668*	*$10,792,816*	*$11,190,067*	*$11,601,940*	*$12,028,973*
Ro-Ro	*$0*	*$0*	*$0*	*$0*	*$0*	*$13,401,701*	*$14,390,414*	*$14,812,645*	*$15,149,416*	*$15,493,881*	*$15,846,216*	*$16,206,601*	*$16,589,707*	*$16,970,810*
Tankers	*$0*	*$10,432,190*	*$10,432,190*	*$24,074,285*	*$24,074,285*	*$59,121,189*	*$59,400,095*	*$106,488,827*	*$97,270,324*	*$98,158,788*	*$85,874,716*	*$86,794,680*	*$87,807,935*	*$88,807,194*
Total:	*$0*	*$19,091,118*	*$19,469,036*	*$33,443,807*	*$33,789,652*	*$82,597,731*	*$84,257,478*	*$132,139,736*	*$123,644,553*	*$125,279,683*	*$113,766,250*	*$115,481,494*	*$117,351,382*	*$119,223,388*

Costs (All Adjusted for Annual Growth) Alternative 2	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
SP Berth Retrofit, New Vaults, and Cable Reel Capital Costs	*$0*	*$8,658,928*	*$8,976,731*	*$9,307,194*	*$9,650,745*	*$10,007,841*	*$10,397,503*	*$10,766,242*	*$11,150,138*	*$11,549,591*	*$11,965,046*	*$12,396,987*	*$12,867,451*	*$13,355,919*
SP Berth Retrofit Maintenance Costs	*$0*	*$0*	*$60,115*	*$62,327*	*$64,622*	*$67,000*	*$69,466*	*$72,023*	*$74,674*	*$77,422*	*$80,272*	*$83,227*	*$86,290*	*$89,466*
Total:	*$0*	*$8,658,928*	*$9,036,846*	*$9,369,521*	*$9,715,367*	*$10,074,841*	*$10,466,969*	*$10,838,265*	*$11,224,812*	*$11,627,014*	*$12,045,318*	*$12,480,214*	*$12,953,741*	*$13,445,385*

Shore Power Vessel Retrofit Costs

Formatting Legend
Value linked from another cell or tab
Calculation

INPUTS:

Fixed Inputs	**Units**	**Value**
Shore Power Retrofit Cost per Vessel - Container/Reefer Vessels	Cost per vessel upgrade ($)	$878,541
Shore Power Retrofit Cost per Vessel - Cruise Vessels	Cost per vessel upgrade ($)	$1,629,682
Shore Power Retrofit Cost per Vessel - Ro-Ro Vessels	Cost per vessel upgrade ($)	$3,163,500
Shore Power Retrofit Cost per Vessel - Tanker Vessels	Cost per vessel upgrade ($)	$2,504,469
CRF (5%, 10 years) for vessels	fraction	0.1295
Shore Power Vessel Equipment Maintenance Costs	Annual Cost per vessel upgrade ($)	$10,000

Vessel Type	**Number of Vessel SP Retrofits - Proposed Reg./Alt. 2**	**Number of Vessel SP Retrofits - Alt. 1**	**Year Begin Construction**
Container/Reefer	57	62	2020
Cruise	26	26	2020
Ro-Ro	0	261	2024
Tankers	0	414	2026

Annual Growth Factors	**Unit**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Compound Growth Factor - Container/Reefer	%	3.9%	8.0%	15.3%	19.4%	23.8%	28.5%	33.4%	41.0%	44.4%	48.2%	52.3%	56.7%	61.4%	69.1%
Compound Growth Factor - Cruise	%	3.7%	7.5%	16.0%	20.2%	24.7%	29.2%	34.0%	38.9%	44.0%	49.3%	54.8%	60.5%	66.5%	72.6%
Compound Growth Factor - Ro-Ro	%	3.7%	7.5%	11.5%	15.1%	18.4%	21.9%	25.4%	29.1%	32.9%	35.9%	39.0%	42.2%	45.4%	48.9%
Compound Growth Factor - Tankers	%	0.5%	1.0%	1.5%	2.7%	3.5%	4.3%	5.1%	5.9%	7.1%	8.2%	9.4%	10.5%	11.7%	13.0%

CALCULATIONS:

Costs (All Adjusted for Annual Growth) Proposed Regulation/Alternative 2*	**Vessel Type**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
1. Shore Power Vessel Retrofit Capital Costs (Incurred by Vessel Operators)	Container/Reefer		*$7,001,417*	*$7,474,306*	*$7,742,062*	*$8,027,481*	*$8,330,915*	*$8,652,811*	*$9,144,132*	*$9,367,427*	*$9,611,796*	*$9,876,736*	*$10,161,967*	*$10,467,388*	*$10,967,607*
	Cruise		*$5,898,503*	*$6,362,966*	*$6,597,168*	*$6,839,990*	*$7,091,750*	*$7,352,776*	*$7,623,409*	*$7,904,004*	*$8,194,927*	*$8,496,557*	*$8,809,290*	*$9,133,534*	*$9,469,712*
2. Shore Power Vessel Retrofit Maintenance Costs (Incurred by Vessel Operators)	Container/Reefer			*$656,961*	*$680,495*	*$705,582*	*$732,253*	*$760,546*	*$803,731*	*$823,358*	*$844,837*	*$868,124*	*$893,195*	*$920,040*	*$964,007*
	Cruise			*$301,500*	*$312,597*	*$324,103*	*$336,032*	*$348,400*	*$361,224*	*$374,520*	*$388,305*	*$402,597*	*$417,415*	*$432,779*	*$448,708*

**Under Alternative 2, no vessel retrofit costs are incurred for Ro-Ro. Under both the Proposed Regulation and Alternative 2, Ro-Ro and Tanker berths are not expected to install shore power.*

Costs (All Adjusted for Annual Growth) Alternative 1	**Vessel Type**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
1. Shore Power Vessel Retrofit Capital Costs (Incurred by Vessel Operators)	Container/Reefer		*$7,615,576*	*$8,129,947*	*$8,421,190*	*$8,731,646*	*$9,061,697*	*$9,411,829*	*$9,946,248*	*$10,189,131*	*$10,454,936*	*$10,743,117*	*$11,053,368*	*$11,385,580*	*$11,929,678*
	Cruise		*$5,898,503*	*$6,362,966*	*$6,597,168*	*$6,839,990*	*$7,091,750*	*$7,352,776*	*$7,623,409*	*$7,904,004*	*$8,194,927*	*$8,496,557*	*$8,809,290*	*$9,133,534*	*$9,469,712*
	Ro-Ro						*$130,327,952*	*$134,134,860*	*$138,067,389*	*$142,118,440*	*$145,349,564*	*$148,654,498*	*$152,034,936*	*$155,492,613*	*$159,168,283*
	Tankers								*$142,244,794*	*$143,803,746*	*$145,325,274*	*$146,869,205*	*$148,436,013*	*$150,026,188*	*$151,777,617*
2. Shore Power Vessel Retrofit Maintenance Costs (Incurred by Vessel Operators)	Container/Reefer			*$714,589*	*$740,188*	*$767,475*	*$796,486*	*$827,261*	*$874,234*	*$895,582*	*$918,946*	*$944,275*	*$971,545*	*$1,000,745*	*$1,048,569*
	Cruise			*$301,500*	*$312,597*	*$324,103*	*$336,032*	*$348,400*	*$361,224*	*$374,520*	*$388,305*	*$402,597*	*$417,415*	*$432,779*	*$448,708*
	Ro-Ro						*$3,181,266*	*$3,274,191*	*$3,370,183*	*$3,469,068*	*$3,547,939*	*$3,628,611*	*$3,711,127*	*$3,795,528*	*$3,885,250*
	Tankers								*$4,385,822*	*$4,433,889*	*$4,480,802*	*$4,528,406*	*$4,576,716*	*$4,625,745*	*$4,679,747*

Equations:

1. Vessels to be Retrofit [#] x Cost per Retrofit [$] x CRF [fraction] x [1 + Compounded Growth Factor [fraction]]

2. Vessels to be Retrofit [#] x Annual Maintenance Cost [$] x [1 + Compounded Growth Factor [fraction]]

SUBTOTALS:

Costs by Vessel Type - Proposed Regulation and Alt. 2*	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	*$0*	*$7,001,417*	*$8,131,267*	*$8,422,557*	*$8,733,063*	*$9,063,168*	*$9,413,357*	*$9,947,863*	*$10,190,785*	*$10,456,633*	*$10,744,860*	*$11,055,162*	*$11,387,428*	*$11,931,615*

Cruise	$0	$5,898,503	$6,664,466	$6,909,765	$7,164,093	$7,427,782	$7,701,176	$7,984,633	$8,278,524	$8,583,231	$8,899,154	$9,226,705	$9,566,313	$9,918,420
Total:	$0	$12,899,920	$14,795,733	$15,332,322	$15,897,156	$16,490,950	$17,114,533	$17,932,496	$18,469,309	$19,039,864	$19,644,015	$20,281,867	$20,953,741	$21,850,035

**Under Alternative 2, no vessel retrofit costs are incurred for Ro-Ro. Under both the Proposed Regulation and Alternative 2, Ro-Ro and Tanker berths are not expected to install shore power.*

Costs (All Adjusted for Annual Growth) Proposed Reg. / Alt. 2	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
SP Vessel Retrofit Capital Costs	$0	$12,899,920	$13,837,272	$14,339,230	$14,867,471	$15,422,665	$16,005,587	$16,767,541	$17,271,431	$17,806,722	$18,373,294	$18,971,257	$19,600,922	$20,437,319
SP Vessel Retrofit Maintenance Costs	$0	$0	$958,460	$993,092	$1,029,685	$1,068,285	$1,108,947	$1,164,955	$1,197,878	$1,233,142	$1,270,721	$1,310,610	$1,352,819	$1,412,716
Total:	$0	$12,899,920	$14,795,733	$15,332,322	$15,897,156	$16,490,950	$17,114,533	$17,932,496	$18,469,309	$19,039,864	$19,644,015	$20,281,867	$20,953,741	$21,850,035

Costs by Vessel Type - Alternative 1	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	$0	$7,615,576	$8,844,536	$9,161,378	$9,499,121	$9,858,183	$10,239,090	$10,820,482	$11,084,713	$11,373,881	$11,687,392	$12,024,913	$12,386,325	$12,978,248
Cruise	$0	$5,898,503	$6,664,466	$6,909,765	$7,164,093	$7,427,782	$7,701,176	$7,984,633	$8,278,524	$8,583,231	$8,899,154	$9,226,705	$9,566,313	$9,918,420
Ro-Ro	$0	$0	$0	$0	$0	$133,509,218	$137,409,052	$141,437,572	$145,587,508	$148,897,502	$152,283,109	$155,746,063	$159,288,140	$163,053,533
Tankers	$0	$0	$0	$0	$0	$0	$0	$146,630,617	$148,237,635	$149,806,076	$151,397,611	$153,012,729	$154,651,933	$156,457,364
Total:	$0	$13,514,080	$15,509,002	$16,071,143	$16,663,214	$150,795,182	$155,349,318	$306,873,304	$313,188,380	$318,660,691	$324,267,266	$330,010,411	$335,892,711	$342,407,565

Costs (All Adjusted for Annual Growth) Alternative 1	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
SP Vessel Retrofit Capital Costs	$0	$13,514,080	$14,492,913	$15,018,358	$15,571,636	$146,481,399	$150,899,465	$297,881,841	$304,015,321	$309,324,699	$314,763,376	$320,333,608	$326,037,914	$332,345,290
SP Vessel Retrofit Maintenance Costs	$0	$0	$1,016,088	$1,052,785	$1,091,578	$4,313,784	$4,449,853	$8,991,463	$9,173,059	$9,335,991	$9,503,890	$9,676,803	$9,854,797	$10,062,274
Total:	$0	$13,514,080	$15,509,002	$16,071,143	$16,663,214	$150,795,182	$155,349,318	$306,873,304	$313,188,380	$318,660,691	$324,267,266	$330,010,411	$335,892,711	$342,407,565

Shore Power Labor and Energy Costs and Cost Savings

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Calculation

INPUTS:

Duration of Emission Control At Berth	Units	Value
Container/Reefer	hours/visit	38.8
Cruise	hours/visit	11.2
Ro-Ro	hours/visit	19.8
Tankers (Average)	hours/visit	40.7

Vessel Auxiliary Engine Effective Power	Units	Value
Average Container/Reefer Vessel Power	kW/vessel	1053
Average Cruise Vessel Power	kW/vessel	5620
Average Ro-Ro Vessel Power	kW/vessel	1159
Average Tanker Vessel Power (Aux. Engines)	kW/vessel	944

Fuel Consumption/LCFS	Units	Value
Brake-Specific Fuel Consumption	g/kW-hr	217
% LCFS Credits Claimed	percent	100%

Labor Cost	Units	Value
Shore Power Connection Labor Costs	Cost per visit ($)	$2,355

Cost Apportionment - SP Labor	Proposed Reg./Alt. 2		Alt. 1	
Port/IMT	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal
Los Angeles	100%	0%	100%	0%
Long Beach	0%	100%	0%	100%
Oakland	0%	100%	0%	100%
San Francisco	0%	100%	0%	100%
San Diego	0%	100%	0%	100%
Hueneme	0%	100%	0%	100%
Stockton Area	▨	▨	0%	100%
Richmond Area	▨	▨	0%	100%
Carquinez Area	▨	▨	0%	100%
Rodeo Area	▨	▨	0%	100%

Cost Apportionment - SP Energy	Proposed Reg./Alt. 2		Alt. 1	
Port	% of Costs Borne by Port	% of Costs Borne by Terminal	% of Costs Borne by Port	% of Costs Borne by Terminal
Los Angeles	0%	100%	0%	100%
Long Beach	0%	100%	0%	100%
Oakland	100%	0%	100%	0%
San Francisco	0%	100%	0%	100%

San Diego	0%	100%	0%	100%
Hueneme	0%	100%	0%	100%
Stockton Area			0%	100%
Richmond Area			0%	100%
Carquinez Area			0%	100%
Rodeo Area			0%	100%

	Annual Vessel Visit Counts for Shore Power Labor				Annual Vessel Visit Counts for Shore Power Energy			
	Proposed Reg./Alt. 2		Alt. 1		Proposed Reg./Alt. 2		Alt. 1	
Years:	**2021-2022**	**2023-2032**	**2021-2022**	**2023-2032**	**2021-2022**	**2023-2032**	**2021-2022**	**2023-2032**
Container/Reefer								
Los Angeles	60	60	60	60	0	0	0	0
Long Beach	18	18	28	28	0	0	0	0
Oakland	125	125	125	125	0	29	0	29
San Diego	0	0	0	0	0	0	0	0
Hueneme	0	0	0	0	0	0	0	0
Total:	*202*	*202*	*212*	*212*	*0*	*29*	*0*	*29*
Cruise								
Years:	**2021-2022**	**2023-2032**	**2021-2022**	**2023-2032**	**2021-2022**	**2023-2032**	**2021-2022**	**2023-2032**
Los Angeles	18	18	18	18	8	12	8	12
Long Beach	0	0	0	0	0	0	0	0
San Francisco	25	25	25	25	17	20	17	20
San Diego	12	12	12	12	3	7	3	7
Total:	*55*	*55*	*55*	*55*	*28*	*39*	*28*	*39*
Ro-Ro								
Years:			**2025**	**2026-2032**			**2025**	**2026-2032**
Los Angeles			90	90			81	84
Long Beach			202	202			181	190
San Francisco			25	25			22	23
San Diego			243	243			217	227
Hueneme			230	230			206	216
Richmond Area			68	68			61	64
Carquinez Area			117	117			105	110
Total:			*975*	*975*			*873*	*914*
POLA/POLB Tankers								
Years:			**2027**	**2028-2032**			**2027**	**2028-2032**
Los Angeles			179	179			160	168
Long Beach			344	344			308	322
Total:			*523*	*523*			*468*	*490*
All Other Tankers Statewide								
Years:			**2029**	**2030-2032**			**2029**	**2030-2032**
Stockton Area			33	33			29	31
Richmond Area			375	375			336	351
Carquinez Area			231	231			207	217
Rodeo Area			104	104			93	97
Total:			*742*	*742*			*665*	*696*

Annual Electricity and Fuel Inputs	**Units**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Projected Electricity Rates - All except Port of San Diego Cruise vessels	$/kW-hr	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.18	$0.19	$0.19

Projected Electricity Rates - Port of San Diego Cruise vessels only	$/kW-hr	$1.16	$1.16	$1.16	$1.16	$1.16	$1.16	$1.16	$1.16	$1.16	$1.16	$1.16	$1.16
Projected MGO Fuel Prices	$/MT	$1,193	$1,242	$1,294	$1,360	$1,409	$1,445	$1,494	$1,547	$1,602	$1,648	$1,707	$1,753
Projected LCFS Credit Value	$/kW-hr	$0.11	$0.11	$0.11	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10	$0.11	$0.11	$0.11
Compound Growth Factor - Container/Reefer	%	19.4%	23.8%	28.5%	33.4%	41.0%	44.4%	48.2%	52.3%	56.7%	61.4%	69.1%	77.2%
Compound Growth Factor - Cruise	%	20.2%	24.7%	29.2%	34.0%	38.9%	44.0%	49.3%	54.8%	60.5%	66.5%	72.6%	78.9%
Compound Growth Factor - Ro-Ro	%	15.1%	18.4%	21.9%	25.4%	29.1%	32.9%	35.9%	39.0%	42.2%	45.4%	48.9%	52.3%
Compound Growth Factor - Tankers	%	2.7%	3.5%	4.3%	5.1%	5.9%	7.1%	8.2%	9.4%	10.5%	11.7%	13.0%	14.3%

CALCULATIONS:

Costs (All Adjusted for Annual Growth) Proposed Regulation/Alternative 2	**Cost Incurred by**	**Vessel Type**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
1. Shore Power Electricity Costs	Terminals	Container/Reefer	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
		Cruise - all except Port of San Diego	$326,774	$335,809	$454,791	$474,051	$496,798	$514,181	$534,678	$557,664	$585,138	$613,640	$638,940	$665,271
		Cruise - Port of San Diego only	$302,829	$313,975	$662,780	$687,175	$712,468	$738,691	$765,880	$794,070	$823,298	$853,601	$885,019	$917,594
1. Shore Power Electricity Costs	Port	Container/Reefer	$0	$0	$272,184	$284,212	$303,588	$310,456	$319,494	$330,259	$343,880	$358,282	$377,005	$396,702
2. Shore Power Labor Costs	Port	Container/Reefer	$167,683	$173,864	$180,436	$187,408	$198,050	$202,886	$208,178	$213,917	$220,094	$226,709	$237,544	$248,897
		Cruise	$50,519	$52,378	$54,306	$56,305	$58,378	$60,526	$62,754	$65,064	$67,459	$69,942	$72,516	$75,185
3. Shore Power Labor Costs	Terminals	Container/Reefer	$401,599	$416,405	$432,144	$448,842	$474,328	$485,911	$498,587	$512,330	$527,125	$542,968	$568,916	$596,108
		Cruise	$104,768	$108,624	$112,622	$116,767	$121,065	$125,521	$130,141	$134,931	$139,898	$145,047	$150,386	$155,921

Cost Savings (All Adjusted for Annual Growth) Proposed Regulation/Alternative 2	**Cost Savings Incurred by**	**Vessel Type**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
4. Shore Power Fuel Savings	Vessel Operator	Container/Reefer	$0	$0	$433,635	$473,195	$518,138	$544,369	$577,569	$614,313	$654,819	$693,811	$752,981	$810,172
		Cruise	$545,549	$588,938	$885,039	$964,076	$1,035,689	$1,101,279	$1,180,651	$1,267,059	$1,361,011	$1,451,505	$1,558,785	$1,659,588
5. LCFS Credit Value	Ports	Container/Reefer	$0	$0	$163,045	$168,197	$169,088	$174,923	$181,703	$188,798	$196,656	$204,779	$218,564	$233,201
	Terminals	Cruise	$226,429	$232,374	$332,770	$342,680	$337,985	$353,877	$371,432	$389,408	$408,741	$428,414	$452,461	$477,698

Costs (All Adjusted for Annual Growth) Alternative 1	**Cost Incurred by**		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
1. Shore Power Electricity Costs	Terminals	Container/Reefer	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
		Cruise - all except Port of San Diego	$326,774	$335,809	$454,791	$474,051	$496,798	$514,181	$534,678	$557,664	$585,138	$613,640	$638,940	$665,271
		Cruise - Port of San Diego only	$302,829	$313,975	$662,780	$687,175	$712,468	$738,691	$765,880	$794,070	$823,298	$853,601	$885,019	$917,594
		Ro-Ro					$4,636,740	$4,986,321	$5,114,722	$5,262,219	$5,446,562	$5,634,376	$5,792,167	$5,950,392
		POLA/POLB Tankers							$3,489,578	$3,713,259	$3,797,973	$3,882,726	$3,944,808	$4,006,645
		All Other Tankers									$5,154,273	$5,514,717	$5,602,894	$5,690,723
1. Shore Power Electricity Costs (Alt 1)	Port	Container/Reefer	$0	$0	$272,184	$284,212	$303,588	$310,456	$319,494	$330,259	$343,880	$358,282	$377,005	$396,702
2. Shore Power Labor Costs	Port	Container/Reefer	$167,683	$173,864	$180,436	$187,408	$198,050	$202,886	$208,178	$213,917	$220,094	$226,709	$237,544	$248,897
		Cruise	$50,519	$52,378	$54,306	$56,305	$58,378	$60,526	$62,754	$65,064	$67,459	$69,942	$72,516	$75,185
		Ro-Ro					$274,079	$282,121	$288,535	$295,096	$301,806	$308,670	$315,967	$323,225
		POLA/POLB Tankers							$456,174	$461,020	$465,938	$470,930	$476,428	$481,849
		All Other Tankers									$0	$0	$0	$0
3. Shore Power Labor Costs	**Terminals**	Container/Reefer	$429,714	$445,556	$462,398	$480,265	$507,535	$519,928	$533,492	$548,197	$564,029	$580,981	$608,745	$637,841
		Cruise	$104,768	$108,624	$112,622	$116,767	$121,065	$125,521	$130,141	$134,931	$139,898	$145,047	$150,386	$155,921
		Ro-Ro					$2,691,222	$2,770,185	$2,833,167	$2,897,587	$2,963,479	$3,030,876	$3,102,522	$3,173,794
		POLA/POLB Tankers							$875,756	$885,060	$894,502	$904,085	$914,639	$925,048

		All Other Tankers									$1,932,028	$1,952,726	$1,975,522	$1,998,004

Cost Savings (All Adjusted for Annual Growth) Alternative 1	Cost Savings Incurred by		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
4. Shore Power Fuel Savings	Vessel Operator	Container/Reefer	$0	$0	$433,635	$473,195	$518,138	$544,369	$577,569	$614,313	$654,819	$693,811	$752,981	$810,172
		Cruise	$545,549	$588,938	$885,039	$964,076	$1,035,689	$1,101,279	$1,180,651	$1,267,059	$1,361,011	$1,451,505	$1,558,785	$1,659,588
		Ro-Ro					$7,913,592	$8,743,259	$9,246,192	$9,788,235	$10,371,381	$10,910,937	$11,568,541	$12,152,300
		POLA/POLB Tankers							$6,308,321	$6,907,019	$7,232,127	$7,518,877	$7,878,859	$8,182,647
		All Other Tankers									$9,814,803	$10,679,219	$11,190,511	$11,621,986
5. LCFS Credit Value	Port	Container/Reefer	$0	$0	$163,045	$168,197	$169,088	$174,923	$181,703	$188,798	$196,656	$204,779	$218,564	$233,201
	Terminal	Cruise	$226,429	$232,374	$332,770	$342,680	$337,985	$353,877	$371,432	$389,408	$408,741	$428,414	$452,461	$477,698
		Ro-Ro					$2,582,510	$2,809,492	$2,908,845	$3,008,241	$3,114,752	$3,220,382	$3,357,945	$3,497,933
		POLA/POLB Tankers							$1,984,593	$2,122,750	$2,171,965	$2,219,210	$2,286,959	$2,355,303
		All Other Tankers									$2,947,599	$3,117,936	$3,188,787	$3,285,181

Equations:

1. Annual Vessel Visits [#] x Aux. Engine Effective Power [kW] x SP Connection Duration [hr] x Electricity Price [$/kW-hr] x [1 + Compounded Growth Factor [fraction]]
2. Σ [Annual Vessel Visits [#],port x % capital cost incurred by port [%],port] x Shore Power Connection Cost per Visit [$] x [1 + Compounded Growth Factor [fraction]]
3. Σ [Annual Vessel Visits [#],port x % capital cost incurred by terminal [%],port] x Shore Power Connection Cost per Visit [$] x [1 + Compounded Growth Factor [fraction]]
4. Annual Vessel Visits [#] x SP Connection Duration [hr] x Aux. Engine Effective Power [kW] x Brake-Specific Fuel Consumption [g/kW-hr] x Fuel Price [$/MT] / 10^6 g/MT x [1 + Compounded Growth Factor [fraction]]
5. Annual Vessel Visits [#] x SP Connection Duration [hr] x Aux. Engine Effective Power [kW] x Electricity Price [$/kW-hr] x Percent Credits Claimed [%] x [1 + Compounded Growth Factor [fraction]]

SUBTOTALS:

Costs by Vessel Type - Proposed Regulation and Alt. 2*	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Container/Reefer	$569,282	$590,269	$884,765	$920,462	$975,965	$999,253	$1,026,260	$1,056,506	$1,091,100	$1,127,959	$1,183,464	$1,241,708
Cruise	$784,889	$810,786	$1,284,499	$1,334,299	$1,388,708	$1,438,919	$1,493,453	$1,551,729	$1,615,792	$1,682,229	$1,746,861	$1,813,971
Total:	$1,354,171	$1,401,055	$2,169,264	$2,254,761	$2,364,674	$2,438,172	$2,519,713	$2,608,235	$2,706,892	$2,810,189	$2,930,325	$3,055,679

**Under Alternative 2, no shore power labor or energy costs are incurred for Ro-Ro. Under both the Proposed Regulation and Alternative 2, Ro-Ro and Tanker vessels are not expected to install shore power.*

Cost Savings by Vessel Type - Proposed Regulation and Alt. 2	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Container/Reefer	$0	$0	$596,680	$641,391	$687,226	$719,292	$759,272	$803,112	$851,475	$898,590	$971,546	$1,043,373
Cruise	$771,978	$821,312	$1,217,809	$1,306,756	$1,373,675	$1,455,156	$1,552,083	$1,656,467	$1,769,752	$1,879,920	$2,011,246	$2,137,286
Total:	$771,978	$821,312	$1,814,489	$1,948,147	$2,060,901	$2,174,449	$2,311,355	$2,459,579	$2,621,227	$2,778,509	$2,982,792	$3,180,659

Costs (All Adjusted for Annual Growth) Proposed Reg. / Alt. 2	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP Electricity Costs	$629,603	$649,784	$1,389,755	$1,445,439	$1,512,854	$1,563,328	$1,620,052	$1,681,993	$1,752,316	$1,825,522	$1,900,964	$1,979,567
SP Labor Costs	$724,568	$751,271	$779,509	$809,322	$851,820	$874,844	$899,660	$926,242	$954,576	$984,666	$1,029,361	$1,076,111
Total:	$1,354,171	$1,401,055	$2,169,264	$2,254,761	$2,364,674	$2,438,172	$2,519,713	$2,608,235	$2,706,892	$2,810,189	$2,930,325	$3,055,679

Cost Savings (All Adjusted for Annual Growth) Proposed Reg. / Alt. 2	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP Fuel Savings	$545,549	$588,938	$1,318,674	$1,437,271	$1,553,827	$1,645,649	$1,758,220	$1,881,372	$2,015,830	$2,145,316	$2,311,766	$2,469,760
SP LCFS Credit Value	$226,429	$232,374	$495,815	$510,876	$507,074	$528,800	$553,135	$578,206	$605,398	$633,194	$671,025	$710,899
Total:	$771,978	$821,312	$1,814,489	$1,948,147	$2,060,901	$2,174,449	$2,311,355	$2,459,579	$2,621,227	$2,778,509	$2,982,792	$3,180,659

Costs by Vessel Type - Alternative 1	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Container/Reefer	$597,397	$619,421	$915,018	$951,885	$1,009,172	$1,033,270	$1,061,165	$1,092,373	$1,128,003	$1,165,972	$1,223,293	$1,283,440
Cruise	$784,889	$810,786	$1,284,499	$1,334,299	$1,388,708	$1,438,919	$1,493,453	$1,551,729	$1,615,792	$1,682,229	$1,746,861	$1,813,971
Ro-Ro	$0	$0	$0	$0	$7,602,041	$8,038,627	$8,236,424	$8,454,901	$8,711,846	$8,973,921	$9,210,656	$9,447,412
Tankers	$0	$0	$0	$0	$0	$0	$4,821,508	$5,059,339	$12,244,714	$12,725,183	$12,914,290	$13,102,269

Total:	$1,382,286	$1,430,207	$2,199,517	$2,286,184	$9,999,922	$10,510,817	$15,612,550	$16,158,342	$23,700,356	$24,547,305	$25,095,100	$25,647,091

Cost Savings by Vessel Type - Alternative 1	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Container/Reefer	$0	$0	$596,680	$641,391	$687,226	$719,292	$759,272	$803,112	$851,475	$898,590	$971,546	$1,043,373
Cruise	$771,978	$821,312	$1,217,809	$1,306,756	$1,373,675	$1,455,156	$1,552,083	$1,656,467	$1,769,752	$1,879,920	$2,011,246	$2,137,286
Ro-Ro	$0	$0	$0	$0	$10,496,102	$11,552,750	$12,155,037	$12,796,475	$13,486,132	$14,131,320	$14,926,486	$15,650,233
Tankers	$0	$0	$0	$0	$0	$0	$8,292,914	$9,029,769	$22,166,494	$23,535,242	$24,545,116	$25,445,117
Total:	$771,978	$821,312	$1,814,489	$1,948,147	$12,557,003	$13,727,199	$22,759,306	$24,285,823	$38,273,853	$40,445,071	$42,454,394	$44,276,009

Costs (All Adjusted for Annual Growth) Alternative 1	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP Electricity Costs	$629,603	$649,784	$1,389,755	$1,445,439	$6,149,594	$6,549,650	$10,224,353	$10,657,471	$16,151,124	$16,857,340	$17,240,832	$17,627,327
SP Labor Costs	$752,684	$780,423	$809,763	$840,745	$3,850,328	$3,961,168	$5,388,197	$5,500,871	$7,549,232	$7,689,965	$7,854,267	$8,019,764
Total:	$1,382,286	$1,430,207	$2,199,517	$2,286,184	$9,999,922	$10,510,817	$15,612,550	$16,158,342	$23,700,356	$24,547,305	$25,095,100	$25,647,091

Cost Savings (All Adjusted for Annual Growth) Alt. 1	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
SP Fuel Savings	$545,549	$588,938	$1,318,674	$1,437,271	$9,467,419	$10,388,907	$17,312,733	$18,576,626	$29,434,140	$31,254,349	$32,949,677	$34,426,693
SP LCFS Credit Value	$226,429	$232,374	$495,815	$510,876	$3,089,584	$3,338,292	$5,446,573	$5,709,197	$8,839,714	$9,190,722	$9,504,717	$9,849,316
Total:	$771,978	$821,312	$1,814,489	$1,948,147	$12,557,003	$13,727,199	$22,759,306	$24,285,823	$38,273,853	$40,445,071	$42,454,394	$44,276,009

Administrative Costs

Formatting Legend
Value linked from another cell or tab
Calculation

INPUTS:

Fixed Inputs	**Units**	**Value**
Port Plan Unit Cost	$ per plan	$10,000
Terminal Plan Unit Cost	$ per plan	$2,500
Terminal Report Cost	$ per vessel visit	$100
Vessel Report Cost	$ per vessel visit	$100
Cost per CARB PY - APS Range C Cost - 1st Yr	$ per PY	$180,000
Cost per CARB PY - APS Range C Cost - subsequent	$ per PY	$179,000
Cost per CARB PY - ARE Range D Cost -1st Yr	$ per PY	$189,000
Cost per CARB PY - ARE Range D Cost - subsequent	$ per PY	$188,000
Cost per CSLC and other State Agency PY - 1st Yr	$ per PY	$189,000
Cost per CSLC and other State Agency PY - subsequent	$ per PY	$188,000
Cost per Other Agency PY - 1st Yr (Local and Federal)	$ per PY	$189,000
Cost per Other Agency PY - subsequent (Local and Federal)	$ per PY	$188,000

Percent of Costs Apportioned	**CARB PY Apportionment**	**Other Agency PY Apportionment**
Container/Reefer	*49%*	*14%*
Cruise	*9%*	*3%*
Ro-Ro	*17%*	*0%*
Tankers - POLA/POLB	*11%*	*36%*
Tankers - All Other	*14%*	*47%*

Cost per CARB PY - ART II - 1st Yr	$ per PY	$88,000
Cost per CARB PY - ART II - subsequent	$ per PY	$87,000

See "Cost Inputs" tab for timing of initial port and terminal plans and terminal plan updates

Annual Inputs		**Units**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Number of Port Plan Terminals - Container/Reefer	All Scenarios	#	9.5	9.5											
Number of Port Plan Terminals - Cruise	All Scenarios	#	2.5	2.5											
Number of Port Plan Terminals - Ro-Ro	Prop. Reg./Alt. 1	#	5.5	5.5											
Number of Port Plan Terminals - **All** Tankers	All Scenarios	#	10	10											
Number of Terminal Plan Berths - Container/Reefer	All Scenarios	#	30	30											
Number of Terminal Plan Berths - Cruise	All Scenarios	#	5.5	5.5											
Number of Terminal Plan Berths - Ro-Ro	Prop. Reg./Alt. 1	#	10.5	10.5		10.5	10.5								
Number of Terminal Plan Berths - POLA/POLB Tankers	All Scenarios	#	6.5	6.5				6.5	6.5						
Number of Terminal Plan Berths - All Other Tankers Statewide	All Scenarios	#	8.5	8.5						8.5	8.5				
Number of Annual Terminal Reports - Container/Reefer	All Scenarios	#		3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742
Number of Annual Terminal Reports - Cruise	All Scenarios	#		527	527	527	527	527	527	527	527	527	527	527	527
Number of Annual Terminal Reports - Ro-Ro	Prop. Reg./Alt. 1	#		1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017
Number of Annual Terminal Reports - POLA/POLB Tankers	All Scenarios	#		610	610	610	610	610	610	610	610	610	610	610	610
Number of Annual Terminal Reports - All Other Tankers Statewide	All Scenarios	#		1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005
Number of Annual Vessel Reports - Container/Reefer	All Scenarios	#		3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742
Number of Annual Vessel Reports - Cruise	All Scenarios	#		527	527	527	527	527	527	527	527	527	527	527	527
Number of Annual Vessel Reports - Ro-Ro	Prop. Reg./Alt. 1	#		1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017	1017
Number of Annual Vessel Reports - POLA/POLB Tankers	All Scenarios	#		610	610	610	610	610	610	610	610	610	610	610	610
Number of Annual Vessel Reports - All Other Tankers Statewide	All Scenarios	#		1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005	1005
Number of CARB PY - APS Range C 1st Yr	All Scenarios	#		3						1					
Number of CARB PY - APS Range C subsequent	All Scenarios	#			3	3	3	3	3	3	4	4	4	4	4
Number of CARB PY - ARE Range D 1st Yr	All Scenarios	#	1												
Number of CARB PY - ARE Range D subsequent	All Scenarios	#		1	1	1	1	1	1	1	1	1	1	1	1
Number of CARB PY - ART - 1st Yr	All Scenarios	#	1	1											
Number of CARB PY - ART - subsequent	All Scenarios	#		2	2	2	2	2	2	2	2	2	2	2	2
Number of CSLC PY - 1st Yr	All Scenarios	#		2											
Number of CSLC PY - subsequent	All Scenarios	#			2	2	2	2	2	2	2	2	2	2	2
Number of Other State Agency PY - 1st Yr	All Scenarios	#		1											
Number of Other State Agency PY - subsequent	All Scenarios	#			1	1	1	1	1	1	1	1	1	1	1
Number of Local Agency PY - 1st Yr	All Scenarios	#		1											
Number of Local Agency PY - subsequent	All Scenarios	#			1	1	1	1	1	1	1	1	1	1	1
Number of Federal Agency PY - 1st Yr	All Scenarios	#		1											
Number of Federal Agency PY - subsequent	All Scenarios	#			1	1	1	1	1	1	1	1	1	1	1

Number of Annual Terminal Reports - Bulk/General Cargo	All Scenarios	#		1043	1043	1043	1043	1043	1043	1043	1043	1043	1043	1043	1043
Number of Annual Vessel Reports - Bulk/General Cargo	All Scenarios	#		1043	1043	1043	1043	1043	1043	1043	1043	1043	1043	1043	1043
Compound Growth Factor - Container/Reefer	All Scenarios	%	15.3%	19.4%	23.8%	28.5%	33.4%	41.0%	44.4%	48.2%	52.3%	56.7%	61.4%	69.1%	77.2%
Compound Growth Factor - Cruise	All Scenarios	%	16.0%	20.2%	24.7%	29.2%	34.0%	38.9%	44.0%	49.3%	54.8%	60.5%	66.5%	72.6%	78.9%
Compound Growth Factor - Ro-Ro	All Scenarios	%	11.5%	15.1%	18.4%	21.9%	25.4%	29.1%	32.9%	35.9%	39.0%	42.2%	45.4%	48.9%	52.3%
Compound Growth Factor - Tankers	All Scenarios	%	1.5%	2.7%	3.5%	4.3%	5.1%	5.9%	7.1%	8.2%	9.4%	10.5%	11.7%	13.0%	14.3%
Compound Growth Factor Weighted by Vessel Type	Prop. Reg./Alt. 1		12.0%	15.5%	19.0%	22.7%	26.6%	32.0%	35.2%	38.4%	41.9%	45.6%	49.4%	55.1%	60.9%
Compound Growth Factor Weighted by Vessel Type	Alt. 2		12.1%	15.5%	19.1%	22.8%	26.1%	32.5%	35.6%	38.9%	42.4%	46.2%	50.2%	56.2%	62.5%

CALCULATIONS:

Costs (All Adjusted for Annual Growth) All Scenarios*	**Cost Incurred by**	**Vessel Type**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
1. Cost of Port Plans	Port	Container/Reefer	$109,493	$113,416	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
		Cruise	$28,990	$30,057	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
		Ro-Ro*	$61,318	$63,307	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
		POLA/POLB Tankers	$101,493	$102,663	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2. Cost of Terminal Plans	Terminal	Container/Reefer	$86,442	$89,539	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
		Cruise	$15,945	$16,532	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
		Ro-Ro*	$29,265	$30,214	$0	$31,995	$32,930	$0	$0	$0	$0	$0	$0	$0	$0
		POLA/POLB Tankers	$16,493	$16,683	$0	$0	$0	$17,215	$17,404	$0	$0	$0	$0	$0	$0
		All Other Tankers	$21,567	$21,816	$0	$0	$0	$0	$0	$22,999	$23,244	$0	$0	$0	$0
3. Cost of Terminal Reporting	Terminal	Container/Reefer	$0	$446,739	$463,209	$480,718	$499,292	$527,643	$540,527	$554,628	$569,916	$586,375	$603,998	$632,862	$663,111
		Cruise	$0	$63,361	$65,693	$68,111	$70,618	$73,217	$75,912	$78,706	$81,603	$84,607	$87,721	$90,950	$94,297
		Ro-Ro	$0	$117,059	$120,454	$123,960	$127,581	$131,321	$135,174	$138,247	$141,391	$144,606	$147,895	$151,391	$154,869
		POLA/POLB Tankers	$0	$62,624	$63,113	$63,609	$64,112	$64,622	$65,330	$66,021	$66,723	$67,435	$68,157	$68,953	$69,737
		All Other Tankers	$0	$103,176	$103,982	$104,798	$105,627	$106,467	$107,634	$108,773	$109,929	$111,101	$112,292	$113,603	$114,895
		Bulk/General Cargo		$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300
4. Cost of Vessel Reporting	Vessel Operator	Container/Reefer	$0	$446,739	$463,209	$480,718	$499,292	$527,643	$540,527	$554,628	$569,916	$586,375	$603,998	$632,862	$663,111
		Cruise	$0	$63,361	$65,693	$68,111	$70,618	$73,217	$75,912	$78,706	$81,603	$84,607	$87,721	$90,950	$94,297
		Ro-Ro	$0	$117,059	$120,454	$123,960	$127,581	$131,321	$135,174	$138,247	$141,391	$144,606	$147,895	$151,391	$154,869
		POLA/POLB Tankers	$0	$62,624	$63,113	$63,609	$64,112	$64,622	$65,330	$66,021	$66,723	$67,435	$68,157	$68,953	$69,737
		All Other Tankers	$0	$103,176	$103,982	$104,798	$105,627	$106,467	$107,634	$108,773	$109,929	$111,101	$112,292	$113,603	$114,895
		Bulk/General Cargo		$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300	$104,300
5. Cost for all new CARB PYs	CARB		$277,000	$990,000	$899,000	$899,000	$899,000	$899,000	$899,000	$1,079,000	$1,078,000	$1,078,000	$1,078,000	$1,078,000	$1,078,000
5. Cost for other state agency PYs including CSLC	State Agencies		$0	$567,000	$564,000	$564,000	$564,000	$564,000	$564,000	$564,000	$564,000	$564,000	$564,000	$564,000	$564,000
5. Cost for all new Local Agency PYs	Local Agencies			$189,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000
5. Cost for all new Federal Agency PYs	Federal Agencies			$189,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000	$188,000

*Under Alternative 2, port plan and terminal plan costs are not incurred for Ro-Ro.

Equations:

1. Port Plans [#] x Cost per Port Plan [$] x [1 + Compounded Growth Factor [fraction]]
2. Terminal Plans [#] x Cost per Terminal Plan [$] x [1 + Compounded Growth Factor [fraction]]
3. Vessel Reports [#] x Cost per Vessel Report [$] x [1 + Compounded Growth Factor [fraction]]
4. Terminal Reports [#] x Cost per Terminal Report [$] x [1 + Compounded Growth Factor [fraction]]
5. Σ [Number of PYs [#] x Cost per PY [$]]

SUBTOTALS:

Costs by Vessel Type - All Scenarios*	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	*$332,165*	*$1,714,568*	*$1,499,104*	*$1,534,122*	*$1,571,271*	*$1,627,972*	*$1,653,741*	*$1,770,467*	*$1,800,551*	*$1,833,469*	*$1,868,716*	*$1,926,444*	*$1,986,942*
Cruise	*$69,910*	*$288,823*	*$238,555*	*$243,391*	*$248,405*	*$253,603*	*$258,993*	*$280,811*	*$286,514*	*$292,522*	*$298,750*	*$305,207*	*$311,902*
Ro-Ro	*$138,264*	*$498,050*	*$395,654*	*$434,661*	*$442,837*	*$417,388*	*$425,094*	*$462,224*	*$468,339*	*$474,769*	*$481,347*	*$488,339*	*$495,294*
POLA/POLB Tankers	*$147,502*	*$691,336*	*$561,466*	*$562,457*	*$563,463*	*$581,698*	*$583,304*	*$586,463*	*$587,759*	*$589,183*	*$590,628*	*$592,219*	*$593,788*
All Other Tankers Statewide	*$60,166*	*$812,369*	*$777,123*	*$778,756*	*$780,413*	*$782,094*	*$784,428*	*$834,787*	*$837,203*	*$816,305*	*$818,685*	*$821,307*	*$823,893*
Bulk/General Cargo (Total)	*$0*	*$208,600*	*$208,600*	*$208,600*	*$208,600*	*$208,600*	*$208,600*	*$208,600*	*$208,600*	*$208,600*	*$208,600*	*$208,600*	*$208,600*
Total:	*$748,006*	*$4,213,746*	*$3,680,501*	*$3,761,987*	*$3,814,989*	*$3,871,355*	*$3,914,160*	*$4,143,352*	*$4,188,967*	*$4,214,847*	*$4,266,725*	*$4,342,116*	*$4,420,419*

**Under Alternative 2, port and terminal plan costs are not incurred for Ro-Ro.*

Costs (All Adjusted for Annual Growth) Proposed Reg. / Alt. 1	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Cost of Port Plans	*$301,294*	*$309,443*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
Cost of Terminal Plans	*$169,712*	*$174,783*	*$0*	*$31,995*	*$32,930*	*$17,215*	*$17,404*	*$22,999*	*$23,244*	*$0*	*$0*	*$0*	*$0*
Cost of Terminal Reporting	*$0*	*$897,260*	*$920,751*	*$945,496*	*$971,529*	*$1,007,570*	*$1,028,878*	*$1,050,676*	*$1,073,862*	*$1,098,424*	*$1,124,363*	*$1,162,058*	*$1,201,210*
Cost of Vessel Reporting	*$0*	*$897,260*	*$920,751*	*$945,496*	*$971,529*	*$1,007,570*	*$1,028,878*	*$1,050,676*	*$1,073,862*	*$1,098,424*	*$1,124,363*	*$1,162,058*	*$1,201,210*
CARB and Other State, Local and Federal Agency PY Costs	*$277,000*	*$1,935,000*	*$1,839,000*	*$1,839,000*	*$1,839,000*	*$1,839,000*	*$1,839,000*	*$2,019,000*	*$2,018,000*	*$2,018,000*	*$2,018,000*	*$2,018,000*	*$2,018,000*
Total:	*$748,006*	*$4,213,746*	*$3,680,501*	*$3,761,987*	*$3,814,989*	*$3,871,355*	*$3,914,160*	*$4,143,352*	*$4,188,967*	*$4,214,847*	*$4,266,725*	*$4,342,116*	*$4,420,419*

Costs (All Adjusted for Annual Growth) Alternative 2	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Cost of Port Plans	*$239,977*	*$246,136*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
Cost of Terminal Plans	*$140,447*	*$144,569*	*$0*	*$0*	*$0*	*$17,215*	*$17,404*	*$22,999*	*$23,244*	*$0*	*$0*	*$0*	*$0*
Cost of Terminal Reporting	*$0*	*$897,260*	*$920,751*	*$945,496*	*$971,529*	*$1,007,570*	*$1,028,878*	*$1,050,676*	*$1,073,862*	*$1,098,424*	*$1,124,363*	*$1,162,058*	*$1,201,210*
Cost of Vessel Reporting	*$0*	*$897,260*	*$920,751*	*$945,496*	*$971,529*	*$1,007,570*	*$1,028,878*	*$1,050,676*	*$1,073,862*	*$1,098,424*	*$1,124,363*	*$1,162,058*	*$1,201,210*
CARB and Other State, Local and Federal Agency PY Costs	*$229,320*	*$1,764,590*	*$1,684,254*	*$1,684,254*	*$1,684,254*	*$1,684,254*	*$1,684,254*	*$1,833,270*	*$1,832,443*	*$1,832,443*	*$1,832,443*	*$1,832,443*	*$1,832,443*
Total:	*$609,743*	*$3,949,815*	*$3,525,755*	*$3,575,245*	*$3,627,313*	*$3,716,609*	*$3,759,414*	*$3,957,622*	*$4,003,409*	*$4,029,290*	*$4,081,168*	*$4,156,559*	*$4,234,862*

Remediation Fee

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Calculation

INPUTS:

Vessel Type	**Vessel Hourly Fee**	**Terminal Hourly Fee**
Container/Reefer	$ 2,395	$ 2,395
Cruise	$ 12,879	$ 12,879
Ro-Ro	$ 1,515	$ 1,515
All Tankers (Average of Product and Crude)	$ 5,828	$ 5,828

Duration of Emission Control At Berth	**Units**	**Value**
Container/Reefer	hours/visit	38.8
Cruise	hours/visit	11.2
Ro-Ro	hours/visit	19.8
Tankers (Average)	hours/visit	40.7

Annual Vessel Visits Subject to Remediation Fee Terminal Upgrades/Construction	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	19	19	19	19	19	19	19	19	19	19	19	19
Cruise	3	3	3	3	3	3	3	3	3	3	3	3
Ro-Ro					5	5	5	5	5	5	5	5
Tankers POLA/POLB							3	3	3	3	3	3
Tankers All Other Statewide									4	4	4	4

Annual Vessel Visits Subject to Remediation Fee Vessel Control Equipment Repair	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	0	0	0	0	0	0	0	0	0	0	0	0
Cruise	0	0	0	0	0	0	0	0	0	0	0	0
Ro-Ro					0	0	0	0	0	0	0	0
Tankers POLA/POLB							1	1	1	1	1	1
Tankers All Other Statewide									0	0	0	0

Annual Growth Factors	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Compound Growth Factor - Container/Reefer	19.4%	23.8%	28.5%	33.4%	41.0%	44.4%	48.2%	52.3%	56.7%	61.4%	69.1%	77.2%
Compound Growth Factor - Cruise	20.2%	24.7%	29.2%	34.0%	38.9%	44.0%	49.3%	54.8%	60.5%	66.5%	72.6%	78.9%
Compound Growth Factor - Ro-Ro	15.1%	18.4%	21.9%	25.4%	29.1%	32.9%	35.9%	39.0%	42.2%	45.4%	48.9%	52.3%
Compound Growth Factor - Tankers	2.7%	3.5%	4.3%	5.1%	5.9%	7.1%	8.2%	9.4%	10.5%	11.7%	13.0%	14.3%

CALCULATIONS:

Remediation Fee Costs - Terminal Upgrades/Construction (All Adjusted for Annual Growth) All Scenarios	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	$2,058,579	$2,134,470	$2,215,152	$2,300,743	$2,431,383	$2,490,756	$2,555,732	$2,626,179	$2,702,021	$2,783,231	$2,916,237	$3,055,623
Cruise	$455,544	$472,311	$489,696	$507,720	$526,407	$545,783	$565,871	$586,700	$608,294	$630,684	$653,897	$677,965
Ro-Ro	$0	$0	$0	$0	$195,557	$201,295	$205,872	$210,553	$215,341	$220,238	$225,445	$230,624
Tankers POLA/POLB	$0	$0	$0	$0	$0	$0	$700,838	$708,283	$715,839	$723,508	$731,954	$740,284
Tankers All Other Statewide	$0	$0	$0	$0	$0	$0	$0	$0	$1,014,761	$1,025,632	$1,037,606	$1,049,414

Remediation Fee Costs - Vessel Control Equipment Repair (All Adjusted for Annual Growth) All Scenarios	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cruise	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Ro-Ro	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tankers POLA/POLB	$0	$0	$0	$0	$0	$0	$242,925	$245,506	$248,125	$250,783	$253,710	$256,598
Tankers All Other Statewide	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Equation

Annual Vessel Visits Subject to Fee [#] x Duration of Visit [hr] x Hourly Fee [$] x [1 + Compounded Growth Factor [fraction]]

SUBTOTALS:

Costs by Vessel Type - All Scenarios	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Container/Reefer	$2,058,579	$2,134,470	$2,215,152	$2,300,743	$2,431,383	$2,490,756	$2,555,732	$2,626,179	$2,702,021	$2,783,231	$2,916,237	$3,055,623
Cruise	$455,544	$472,311	$489,696	$507,720	$526,407	$545,783	$565,871	$586,700	$608,294	$630,684	$653,897	$677,965
Ro-Ro	$0	$0	$0	$0	$195,557	$201,295	$205,872	$210,553	$215,341	$220,238	$225,445	$230,624
Tankers POLA/POLB	$0	$0	$0	$0	$0	$0	$943,762	$953,789	$963,964	$974,291	$985,665	$996,882
Tankers All Other Statewide	$0	$0	$0	$0	$0	$0	$0	$0	$1,014,761	$1,025,632	$1,037,606	$1,049,414
Total:	$2,514,123	$2,606,782	$2,704,848	$2,808,463	$3,153,348	$3,237,834	$4,271,238	$4,377,220	$5,504,381	$5,634,076	$5,818,849	$6,010,508

Costs - All Scenarios	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Remediation Fee Costs - Terminal	$2,514,123	$2,606,782	$2,704,848	$2,808,463	$3,153,348	$3,237,834	$4,028,314	$4,131,715	$5,256,257	$5,383,293	$5,565,139	$5,753,910
Remediation Fee Costs - Vessel	$0	$0	$0	$0	$0	$0	$242,925	$245,506	$248,125	$250,783	$253,710	$256,598
Total:	$2,514,123	$2,606,782	$2,704,848	$2,808,463	$3,153,348	$3,237,834	$4,271,238	$4,377,220	$5,504,381	$5,634,076	$5,818,849	$6,010,508

Port Analysis
Port of Long Beach - Proposed Regulation

Formatting Legend
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Calculation

Total Costs to Port - POLB	Costs Incurred by	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total 2020 - 2032
	Port	$8,092,857	$8,022,857	$8,022,857	$8,052,857	$27,789,159	$27,976,461	$28,164,817	$21,412,717	$21,640,205	$21,871,063	$22,105,365	$22,363,427	$22,617,924	$248,132,566

Land-Based Capture & Control Costs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Capital Costs (all POLB/POLA)					$36,708,846	$37,000,979	$37,406,496	$37,802,279	$38,203,889	$38,611,450	$39,025,089	$39,480,674	$39,929,966
Capital Costs (all POLB only)					*$19,766,302*	*$19,923,604*	*$20,141,959*	*$20,355,073*	*$20,571,325*	*$20,790,781*	*$21,013,510*	*$21,258,825*	*$21,500,751*
Feasibility Study Costs (all POLB/POLA)	$928,571	$928,571	$928,571	$928,571	$928,571	$928,571	$928,571						
Feasibility Study Costs (POLB only)	*$500,000*	*$500,000*	*$500,000*	*$500,000*	*$500,000*	*$500,000*	*$500,000*						
Engineering Costs (all POLB/POLA)	$10,478,266	$10,478,266	$10,478,266	$10,478,266	$10,478,266	$10,478,266	$10,478,266						
Engineering Costs (POLB only)	*$5,642,143*	*$5,642,143*	*$5,642,143*	*$5,642,143*	*$5,642,143*	*$5,642,143*	*$5,642,143*						
Permitting Costs (POLB/POLA only)	$3,492,755	$3,492,755	$3,492,755	$3,492,755	$3,492,755	$3,492,755	$3,492,755						
Permitting Costs (POLB only)	*$1,880,714*	*$1,880,714*	*$1,880,714*	*$1,880,714*	*$1,880,714*	*$1,880,714*	*$1,880,714*						

POLB Tanker berths	7
POLA Tanker berths	6
POLB Tanker terminals	3

POLB Container/Reefer terminals	6
POLB Cruise terminals	1
POLB Ro-Ro terminals	3

Port Plan Unit Cost per terminal	$10,000

Shore Power Costs	Costs/Savings Incurred by	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total 2020 - 2032
Berth Infrastructure	Port	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Net Total		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Land-Based Capture and Control Costs - Tankers	Costs/Savings Incurred by	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total 2020 - 2032
Capital Costs	Port	$0	$0	$0	$0	$19,766,302	$19,923,604	$20,141,959	$20,355,073	$20,571,325	$20,790,781	$21,013,510	$21,258,825	$21,500,751	$185,322,129
Maintenance Costs	Port	$0	$0	$0	$0	$0	$0	$0	$1,057,643	$1,068,880	$1,080,283	$1,091,856	$1,104,602	$1,117,172	$6,520,436
Feasibility	Port	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$0	$0	$0	$0	$0	$0	$3,500,000
Engineering	Port	$5,642,143	$5,642,143	$5,642,143	$5,642,143	$5,642,143	$5,642,143	$5,642,143	$0	$0	$0	$0	$0	$0	$39,495,001
Permitting	Port	$1,880,714	$1,880,714	$1,880,714	$1,880,714	$1,880,714	$1,880,714	$1,880,714	$0	$0	$0	$0	$0	$0	$13,165,000
Total		$8,022,857	$8,022,857	$8,022,857	$8,022,857	$27,789,159	$27,946,461	$28,164,817	$21,412,717	$21,640,205	$21,871,063	$22,105,365	$22,363,427	$22,617,924	$248,002,566

Land-Based Capture and Control Costs - Ro-Ro	Costs/Savings Incurred by	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total 2020 - 2032
Capital Costs	Port	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Barge-Based Capture and Control: No costs for POLB (costs incurred by vessel operators and technology developers only.)

Administrative and Remediation	Costs Incurred by	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total 2020 - 2032
Port Plans	Port	$70,000			$30,000		$30,000								$130,000
Total		$70,000	$0	$0	$30,000	$0	$30,000	$0	$0	$0	$0	$0	$0	$0	$130,000

Port Analysis

Port of Hueneme - Proposed Regulation

Total Costs to Port - Hueneme	Costs Incurred by	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total 2020 - 2032
	Port	$10,000	$0	$0	$30,000	$351,914	$362,193	$372,812	$383,751	$392,475	$401,399	$410,527	$419,864	$429,789	$3,564,725

Land-Based Capture & Control Costs	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Capital Costs					*$351,914*	*$362,193*	*$372,812*	*$383,751*	*$392,475*	*$401,399*	*$410,527*	*$419,864*	*$429,789*

Shore Power Costs	Costs/Savings Incurred by	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total 2020 - 2032
Berth Infrastructure	Port	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Net Total		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

Barge-Based Capture and Control: No costs for Hueneme (costs incurred by vessel operators only.)

Container/Reefer Terminals	1
Ro-Ro Terminals	3
Port Plan Unit Cost per terminal	$10,000

Administrative and Remediation	Costs Incurred by	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Total 2020 - 2032
Port Plans	Port	$10,000			$30,000										$40,000
Total		$10,000	$0	$0	$30,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$40,000

APPENDIX C

CARB Staff Analysis of Potential Emission Reduction Strategies by Port/Terminal/Berth

Container and Refrigerated Cargo (Reefer) Vessels

Cruise/Passenger Vessels

Auto/Ro-Ro Vessels

Crude and Product Tanker Vessels

August 1, 2019

The berth analysis is an assessment made by California Air Resources Board (CARB) staff to characterize what additional shore power infrastructure improvements and potential emission control technologies (land- or barge-based alternative capture and control systems) may be necessary to support the new draft At Berth Regulation. For the development of the analysis, CARB staff relied on port maps, Google Earth maps, and vessel visit information from Wharfinger, San Francisco Marine Exchange, and California State Lands Commission data. CARB staff's assessment was based on comment letters received from industry stakeholders in response to the new draft At Berth Regulation, numerous port/terminal site visits and tours, extensive discussions with terminal operators, Port staff throughout the state, and harbor pilots servicing the Northern and Southern California Ports.

The assessment is also intended to assist CARB staff to estimate the potential cost impacts that could be incurred due to infrastructure and/or equipment upgrades as a result of the requirements of the new draft At Berth Regulation.

Container and Refrigerated Cargo (Reefer) Vessels

Legend:

C+C= capture and control system SP= shore power

Prop 1B = In 2006, California voters approved Proposition 1B (Prop 1B) which authorizes $1 billion in bond funding to CARB to reduce freight related emissions in the State's trade corridor. The program focuses on funding cleaner equipment or related infrastructure for various emission sources, including port-related equipment such as shore power and emissions capture and control systems.

* Prop 1B Funding, Performance Option 1 - Plug in requirement is a percentage of all visits to the berth by vessels regulated under the existing At-Berth Regulation

** Prop 1B Funding, Performance Option 2 - Plug in requirement is a percentage of all visits to the berth by all vessels visiting the berth

*** Prop 1B Funding for these berths were an early grant prior to the Performance Options; requirement is for a percentage of all ship visits. This grant required the installation of 3 vaults at berths 60-63 (grantee chose which berths)

Subject Headers:

- **Prop 1B Berth?** = Indicates which specific berth at a port/terminal was funded through Prop 1B for shore power infrastructure and plug in performance requirements
- **Total # Container & Reefer Visits in 2017** = Total number of container and reefer vessel visits by berth based on 2017 visit information
(visit information includes vessel visits made by vessels subject to the existing At-Berth Regulation and unregulated vessels)
- **# of Anticipated Newly Regulated Vessel Visits** = Number of visits made by container and reefer vessels currently not subject to the existing At-Berth Regulation
- **# of Existing Vaults** = Number of existing land-side vaults installed (to connect vessel-based shore power to land-side shore power)
- **Additional SP Infrastructure Assumed?** = Staff's estimates of potential infrastructure needs based on number of vessels that are currently not subject to the existing At-Berth Regulation and vessels that are currently subject to the regulation but will be required to meet vessel visit requirements once the new At Berth Regulation becomes effective
- **Estimated # of Additional C+C Systems Needed** = Number of emission capture and control system (land-or barge -based) that CARB staff's analysis indicates may be most feasible for use per port
- **Reasoning** = Basis for CARB staff analysis and assumptions

Cruise/Passenger Vessels

Legend:
C+C= capture and control system
SP= shore power

Subject Headers:

-**Total # of Cruise Visits in 2017** = Total number of passenger/cruise vessel visits by berth based on 2017 visit information (visit information includes vessel visits made by vessels subject to the existing At-Berth Regulation and unregulated vessels)

- **# of Anticipated Newly Regulated Vessel Visits** = Number of visits made by passenger/cruise vessel currently not subject to the existing At-Berth Regulation

- **# of Existing Vaults** = Number of existing land-side vaults installed (to connect vessel-based shore power to land-side shore power) - **Additional SP Infrastructure Needed** = Staff's estimate of potential landside infrastructure needs for newly covered vessels that are currently not subject to the existing At-Berth Regulation

- **Additional SP Infrastructure Needed?** = Staff's estimates of potential infrastructure needs based on number of vessels that are currently not subject to the existing At-Berth Regulation and vessels that are currently subject to the regulation but will be required to meet vessel visit requirements once the new At Berth Regulation becomes effective

-**Reasoning** = Basis for CARB staff analysis and assumptions

Auto/Ro-Ro Vessels

Legend:
C+C= capture and control system
SP= shore power

Subject Headers:
- **# of Auto/Ro-Ro Visits in 2017** = Total number of auto/Ro-Ro vessel visits by berth based on 2017 visit information
- **# of Frequent Auto & Ro-Ro Vessels Visiting Terminal in 2017 =** Number of frequent (vessel that visits the same berth in California at least 4 times in a year) auto/Ro-Ro vessels by port
- **# of Visits by Frequent Auto & Ro-Ro Vessels in 2017** = Number of visits made by frequent auto/ro-ro vessels
- **Estimated # of C+C Systems Needed** = Number of emission capture and control system (land-or barge-based) that CARB staff estimates will be necessary per port
- **Assumed Control Technology** = Type of emissions control technology that CARB staff's analysis indicates may be most feasible for use
- **Improvements to Existing Infrastructure Needed?** = Additional landside infrastructure improvements needed to support the emission control technology assumption for a given port/marine terminal complex (in some situations infrastructure upgrades, such as wharf improvements may be necessary to support a land-based emission control strategy)
- **Reasoning** = Basis for CARB staff analysis and assumptions

Crude and Product Tanker Vessels

Legend:

C+C= capture and control system
SP= shore power
Spud barge= is a type of barge that is moored by using through-deck pilings or steel shafts

Subject Headers:

- **# of Tanker Visits in 2017** = Total number of tanker vessel visits by berth based on 2017 visit information
- **# of Frequent Tanker Vessels Visiting Terminals in 2017 =** Number of frequent (vessel that visits the same berth in California at least 4 times in a year) tanker vessels by port/marine terminal complex
- **# of Visits by Frequent Tanker Vessels in 2017** = Number of visits made by frequent tanker vessels by port/marine terminal complex
- **Assumed Control Technology & Estimated # of C+C Systems Needed** = Type of emissions control technology that CARB staff's analysis indicates may be most feasible for use and estimated number of emission capture and control system (land-or barge-based) that CARB staff estimates will be necessary per port/marine terminal complex
- **Additional Infrastructure Improvements Needed?** = Additional landside infrastructure improvements needed to support the emission control technology assumption for a given port/marine terminal complex (in some situations infrastructure upgrades, such as wharf improvements may be necessary to support a land-based emission control strategy)
- **Reasoning** = Basis for CARB staff analysis and assumptions

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
Hueneme	**3**	**155**	**0**	**0**	**6**	**No**	**0**	**Hueneme will continue to rely on SP for compliance, as all reefer berths are SP capable. Port already owns a cable reel management system.**
Wharf 1	3	155	0	0	6	No	0	Wharf 1 has SP at all three berths. Port staff advised CARB staff that they have already purchased a cable reel management system, but are unable to use it at this time due to design flaws. Due to space and navigation constraints, barge-based C+C systems are not feasible at Wharf 1. Berths are all Prop 1B berths; not assuming any additional infrastructure needed.
Berth B1	Yes, Option 1*	1	0	0	2	No	0	All berths have SP; up to three vessels can use SP at the same time.
Berth B2	Yes, Option 1*	117			2			
Berth B3	Yes, Option 1*	37			2			

One berth used 190 days of the year, two berths used at same time 67 days of the year (in 2017)

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
Long Beach	**11**	**909**	**89**	**34**	**75**	**No**	**1 additional C+C (shared across POLB/POLA) - Terminals need access to an estimated 1 additional barge-based C+C system**	**POLB will continue to primarily rely on SP for compliance.**
SSA - Pier A	3	225	36	14	9	No	1 (shared access across Port)	Terminal staff advised CARB staff that this terminal will continue to rely on SP for compliance. Terminal staff advised that Pier A sees limited vessel sizes due to bridge and channel restrictions; no purchase of a cable reel management system is anticipated. Vessels berth only Port side due to Pilots preference for safe navigation. Terminal may need occasional access to barge-based C+C system for vessels with SP connection only on starboard side, but no dedicated system. Terminal staff confirmed a barge-based C+C system will fit alongside vessels if needed. No additional vaults assumed due to low frequency of all berths being used at the same time, and because all berths are Prop 1B berths; not assuming any additional infrastructure needed.
A92	Yes, Option 2**	43			3	No		
A94	Yes, Option 2**	104	36	14	3	No	0	All berths have SP; up to three vessels can use SP at the same time.
A96	Yes, Option 2**	78			3	No		
One berth used 176 days of the year, two berths used at same time 114 days of the year, three berths used at same time 17 days of the year (in 2017)								
SSA - Pier C	0	82	9	0	8	No	0	Pier C staff advised CARB staff this is a dedicated terminal that will continue to rely solely on SP for compliance. No purchase of additional cable reel management systems are anticipated. No additional vaults assumed as terminal staff indicates they primarily only use one berth and one vault.
C60	No	1	9	0	4	No	0	The terminal has two SP-capable berths, but typically uses only one; the terminal also has 8 vaults in total.
C62	No	81			4	No		
One berth used 316 days of the year, two berths used at same time 19 days of the year (in 2017) - includes both container and con-ro vessel visits								

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
Long Beach Container Terminal - Pier E	0	83	5	3	15	No	0	Lease with POLB already requires 100% controls (either SP or barge-based bonnet C+C system is currently used for compliance), so CARB staff not assuming any additional infrastructure needed. Per conversation with terminal staff, LBCT can plug in 2 vessels at a time - one at each berth. Terminal already owns two cable reel management systems. Third berth (E22) is currently under construction, and should be finished by early 2022 at the latest. Berth E22 will also be SP capable and terminal will have enough power for all vessels to plug in at all three berths at the same time.
E22	No	Under Construction	Under Construction	Under Construction	5	Under Construction	0	Pier E will be installing 5 SPOs as part of Phase 3 of the Middle Harbor Project at Long Beach Container Terminal.
E24	No	34	5	3	5	No		Both existing berths have SP. Terminal has enough power to supply SP to both berths at the same time.
E26	No	49			5			
One berth used 231 days of the year, two berths used at same time 78 days of the year (in 2017)								
International Transportation Service - Pier G	1	146	14	2	12	No	1 (shared access across Port)	Per CARB staff information Berths G232 and G236 have SP. Have not been able to confirm with Terminal about how many vessels can plug into SP at the Terminal at the same time; assuming no additional power needed at this time. SP infrastructure, operational changes, or access to a barge-based C+C system may be needed at berth G235, but no dedicated system (to be confirmed with Terminal). No additional vaults assumed at this terminal.
G232	No	53	14	2	5	No	1 (shared across Port)	Berth has SP - Port of LB installed
G235	No	25			1	No		Berth has limited SP usage; built for a specific vessel design. Vessel must be a certain size (5500 TEU and smaller), can only use AMP box if located at aft end.
G236	Yes, Option 2**	68			6	No		Berth has SP - Port of LB installed
One berth used 117 days of the year, two berths used at same time 160 days of the year, three berths used at same time 27 days of the year (in 2017)								

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
Pacific Container Terminal - Pier J	4	138	18	11	20	No	1 (shared access across Port)	Pier J staff confirmed terminal will continue to rely on SP for compliance. Terminal staff informed CARB staff that vessels berth port-side at berths J245-J247 (north berths) and starboard-side at J266-J270 (south berths) due to safety of terminal container yard operations. North berths have 1 substation, south berths have 2 substations. Can energize up to four vessels at a time, but only three vessels fit due to vessel size constraints at this time. Terminal staff advised no cable reel needed unless there is a significant change to the types of vessels calling this terminal. Terminal may need occasional access to barge-based C+C system for vessels with SP connection only on one side, but no dedicated system. No additional vaults assumed due to low frequency of all berths being used at the same time, and because berths are all Prop 1B berths; not assuming any additional infrastructure needed.
J245	Yes, Option 2**	52	18	11	9	No	1 (shared across Port)	Berth has SP; vessels calling this berth will be positioned on port-side. This is the main berth used on the north side of the terminal.
J246	No	0				No		Berth has SP; vessels calling this berth will be positioned on port-side. Typically only used when berth J245 is not available.
J247	Yes, Option 2**	0				No		Berth has SP; vessels calling this berth will be positioned on port-side. Low number of visits to this berth, as the size of the berth makes it only useable for smaller vessels.
J266	Yes, Option 2**	65			11	No		Berth has SP; vessels calling this berth will be positioned on starboard-side. This is the main berth used on the south side of the terminal.
J270	Yes, Option 2**	21				No		Berth has SP; vessels calling this berth will be positioned on starboard-side. This berth is typically used when berth J266 is not available.
One berth used 147 days of the year, two berths used at same time 153 days of the year, three berths used at same time 30 days of the year (in 2017)								
Total Terminals Inc. - Pier T	3	235	7	4	11	No	0	Pier T can energize four vessels at a time, but due to current vessel size and alignment constraints, can plug in a maximum of three vessels at a time. Terminal already owns one 100 foot cable reel management system, but can only use on vessels with aft AMP connection due to wharf space constraints. Vessels can berth port or starboard side due to location next to large turning basin. Terminal recently completed vault relocation; no additional vault installation assumed at this time.
T132	No	1	7	4			0	
T134	No	124			4	No		Berth has SP
T136	Yes, Option 2**	55			2	No		Berth has SP
T138	Yes, Option 2**	12			3	No		Berth has SP
T140	Yes, Option 2**	43			2	No		Berth has SP
One berth used 83 days of the year, two berths used at same time 138 days of the year, three berths used at same time 117 days of the year (in 2017)								

[1] Per POLB, the port has 78 total vaults; confirming location of 8 additional vaults

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
Los Angeles	**10**	**1029**	**123**	**21**	**70**	**Yes - additional 2 vaults at WBCT Berths 121 and 126**	**1 additional C+C (shared across POLA/POLB) - Terminals need access to an estimated 1 additional barge-based C+C system**	**POLA will continue to primarily rely on SP for compliance, with some use of the barge-based system for non-SP capable vessels or for situations where the terminal is unable to connect a SP-capable vessel to SP for operational reasons.**
APM	5	202	10	3	20	No	0	All of APM's active berths from 2017 are SP capable; up to 6 vessels can be connected to SP at the same time. Vessels can berth port or starboard-side, with starboard-side being typical. Terminal has a large turning basin nearby that allows access for turning vessels. Terminal has a high number of existing vaults and all are Prop 1B berths; not assuming any additional infrastructure needed.
Berth 401	Yes, Option 2**	1	10	3	4	No	0	Berth has SP and a low # of visits
Berth 402	Yes, Option 2**	54			4			Berth has SP
Berth 403	Yes, Option 2**	60			4			Berth has SP
Berth 404	Yes, Option 2**	62			4			Berth has SP
Berth 405****	Yes, Option 2**	25			4			Berth has SP, but no visits in 2017
One berth used 108 days of the year, two berths used at same time 148 days of the year, three berths used at same time 70 days of the year, four berths used at same time 28 days of the year (in 2017								
Everport	1	142	5	2	3	No	0	All of Terminal's active berths from 2017 are SP capable, with no visits recorded from unregulated vessels. Terminal staff confirmed they can plug in 2 vessels at the same time. Port is adding an additional 5 total vaults in the 2019-2021 timeframe. No cable reel considered for this terminal due to installation of new vaults occuring in 2019-2021.
Berth 227	Yes, Option 2**	82	5	2	2	No	0	Berth has SP; port adding 2 additional vaults
Berth 230	No	60			1			Berth has SP; port adding 3 additional vaults
One berth used 143 days of the year, two berths used at same time 202 days of the year (in 2017)								
Fenix Marine	0	132	19	10	15	No	0	All of Terminal's active berths from 2017 are SP capable per CARB staff information. Confirming with Terminal about how many vessels can plug into SP at the same time.
Berth 302	No	68	19	10	4	No	0	Berth has SP
Berth 303	No	43			4			Berth has SP
Berth 304	No	19			4			Berth has SP
Berth 305	No	2			3			Berth has SP
One berth used 123 days of the year, two berths used at same time 180 days of the year, three berths used at same time 51 days of the yea (in 2017)								

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
TraPac	0	99	3	1	10	No	0	Terminal only uses berths 139, 144, and 147; all three have SP and can energize three vessels at a time. No need for a cable reel management system is anticipated, as terminal staff advised CARB staff that they plan vessel berthing positions around where vessel AMP connections are located. Terminal staff advised CARB staff the terminal has an existing mitigation requirement to control 100% of emissions (SP or C+C system), so no additional infrastructure assumed at this terminal.
Berth 136	No	0	3	1	2	No	0	Berth has SP
Berth 139	No	45			2			Berth has SP
Berth 144	No	46			2			Berth has SP
Berth 147	No	8			4			Berth has SP
One berth used 247 days of the year, two berths used at same time 99 days of the year, three berths used at same time 3 days of the year (in 2017)								
WBCT - China Shipping	0	118	2	0	8	No	0	WBCT consists of the China Shipping dock and the Yang Ming dock. The terminal has four total SP capable berths, and can energize a maximum of four vessels at a time. Three vessels is maximum that will fit at the berths at any one time due to space and alignment constraints. China Shipping berths have an existing mitigation requirement to control 100% (+/- 5%) of all vessels calling berths 100 and 102, so no additional infrastructure is assumed for these berths. Per terminal staff, terminal is considering a cable reel for the China Shipping berths to increase plug ins.
China Shipping - Berth 100	No	67	2	0	4	No	0	Berth has SP
China Shipping - Berth 102	No	51			4			Berth has SP
One berth used 167 days of the year, two berths used at same time 150 days of the year (in 2017)								
WBCT - Yang Ming	2	115	78	3	4	Yes - Additional 2 vaults at Berths 121 and 126	1 (shared across Port)	WBCT consists of the China vesselping dock and the Yang Ming dock. The terminal has four total SP capable berths, and can energize a maximum of four vessels at a time. Three vessels is maximum that will fit at the berths at any one time due to space and alignment constraints. Per Terminal staff, vessels calling Yang Ming berths can only plug in if SP connection is in the middle of the vessel (near the house), and cannot plug in if connection is at the stern. Terminal staff advised that cable reel management system will not work at Berths 121 and 126, as there is not a cable reel long enough to correct alignment issues; Berths 121 and 126 need additional vaults to plug in 100% of vessels. Normal operations are to berth port side-to; terminal can berth starboard side-to also, but ability to do so depends on alignment of vessels at the berth.
Yang Ming - Berth 121	Yes, Option 2**	74	78	3	2	Additional 1 vault	1 (shared across Port)	Berths have SP; these berths see a high number of visits from currently unregulated steam ship vessels.
Yang Ming - Berth 126	Yes, Option 2**	41			2	Additional 1 vault		
One berth used 179 days of the year, two berths used at same time 100 days of the year (in 2017)								

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
Yusen	2	221	6	2	10	No	0	All of Terminal's active berths from 2017 are SP capable per CARB staff information. No information received from Terminal about how many vessels can plug into SP at the same time. Terminal has a high number of existing vaults and 2 of 3 are Prop 1B berths; not assuming any additional infrastructure needed.
Berth 212	Yes, Option 2**	106			2			Berth has SP
Berth 214	No	46	6	2	4	No	0	Berth has SP
Berth 218	Yes, Option 2**	69			4			Berth has SP

One berth used 78 days of the year, two berths used at same time 205 days of the year, three berths used at same time 75 day of the year (in 2017)

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
Oakland	**6 berths, plus 3 vaults at Matson Terminal**	**1597**	**191**	**0**	**31**	**Yes - additional 3 vaults at OICT**	**0**	**Port of Oakland will continue to rely on SP for compliance with the expanded regulation. Each berth has its own substation, so no additional power is needed. Barge-based C+C looks to be an option for TraPac terminals, but not Nutter, Matson or OICT due to concerns expressed from SF Bar Pilots about wave interaction from passing vessels and channel space and navigational constraints.**
Everport (Nutter)	2	153	6	0	4	No	0	Nutter Terminal will continue to rely on SP for compliance with the regulation; both berths are SP capable and can plug two vessels in at the same time. Berths are all Prop 1B berths; not assuming any additional infrastructure needed.
Berth 35	Yes, Option 2**	99	6	0	2	No	0	Berth has SP
Berth 37	Yes, Option 2**	54			2			Berth has SP
* One berth used 260 days of the year, two berths used at same time 0 days of the year (in 2017)								
Matson	3 vaults	107	59	0	3	No	0	This terminal has SP and will continue to rely on SP for compliance with SP capable vessels. Terminal installed 3 vaults with Prop 1B funding; not assuming any additional infrastructure needed.
Berth 61	Yes***	0	59	0	3	No	0	This berth has SP and a low number of visits, so compliance is expected to be met with SP-capable vessels.
Berth 62	Yes***	99				No		This berth has SP, and receives a high number of both SP and non-SP vessels.
Berth 63	Yes***	8			0	No		This berth has SP and a low number of visits, so compliance is expected to be met with SP-capable vessels.
One berth used 240 days of the year, two berths used at same time 13 days of the year, three berths used at same time 1 day of the year (in 2017) - includes both container and con-ro vessel visits								
OICT	2	1072	113	0	18	Yes - additional 3 vaults	0	OICT will continue to rely on SP for compliance with SP capable vessels. This terminal has SP at every berth, with enough power capacity to plug in a vessel at every berth, but terminal staff has advised CARB staff that 3 additional vaults are needed. OICT has a cable reel managaement system, but labor has red-tagged the equipment and they are unable to use it at this time.
Berth 55	Yes, Option 2**	212	113	0	3	3 additional vaults	0	SP will continue to be primary pathway to compliance. Can energize five vessels at the same time, but only four vessels will fit plugged in at a time due to vessel size and positioning issues. Terminal already owns cable reel management system, but unable to use due to labor safety concerns.
Berth 56	No	255			4			
Berth 57	No	236			4			
Berth 58	No	224			4			
Berth 59	Yes, Option 2**	145			3			
One berth used 4 days of the year, two berths used at same time 35 days of the year, three berths were used at same time 103 days of the year, four berths were used at same time 166 times of the year, five berths were used at								
TraPac	2	265	13	0	6	No	0	TraPac Terminal will continue to rely on SP for compliance with the regulation; both berths are SP capable and can plug two vessels in at the same time. Berths are all Prop 1B berths; not assuming any additional infrastructure needed.
Berth 30	Yes, Option 2**	101	13	0	3	No	0	Berth has SP
Berth 32	Yes, Option 2**	164			3			Berth has SP
One berth used 246 days of the year, two berths used at same time 100 days of the year (in 2017)								

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	Prop 1B Berth?	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	# of Existing Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed	Reasoning
San Diego	**0**	**52**	**0**	**0**	**3**	**No**	**0**	**Reefers visiting Port of San Diego will rely on SP for compliance. Port can plug in one reefer vessel at a time, but since only one vessel typically calls berth at a time, no additional power or infrastructure assumed necessary.**
Tenth Avenue Terminal	0	52	0	0	3	No	0	Reefer terminal will continue to rely on SP for compliance with the regulation. All berths are SP capable, and only one berth typically used at a time, so no additional infrastructure assumed necessary at this terminal. Terminal has a cable management system available for use.
Berth 10-2	No	6	0	0	1	No	0	All reefer vessels calling San Diego were regulated as of 2017, with no major concerns about vessels plugging in.
Berth 10-3	No	31			1			
Berth 10-4	No	15			1			

One berth used 173 days of the year, two berths used at same time 0 days of the year (in 2017)

Port/Terminal/Berth	# of Prop 1B Berths	Total # of Container & Reefer Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Visits from Infrequent Vessels Not Anticipated To Install SP	Total # of Vaults	Additional SP Infrastructure Assumed?	Estimated # of Additional C+C Systems Needed
Statewide #'s	**30 individual berths, plus 3 vaults at Matson - Oakland**	3742	403	55	185	**5 vault installations**	**1 additional Barge-based C+C**

* Prop 1B Funding, Performance Option 1 - Plug in requirement is a percentage of all visits to the berth by vessels regulated under the existing At-Berth Regulation

** Prop 1B Funding, Performance Option 2 - Plug in requirement is a percentage of all visits to the berth by all vessels visiting the berth

*** Prop 1B Funding for these berths were an early grant prior to the Performance Options; requirement is for a percentage of all vessel visits.
This grant required the installation of 3 vaults at berths 60-63 (grantee chose which berths)

****These 25 visits were previously under Berth 406, but Port of LA advised us Berth 406 is not in use; reassigned visits to Berth 405

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	Total # of Cruise Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Existing Vaults	Additional SP Infrastructure Needed?	Reasoning
Long Beach	**256**	**0**	**1**	**No**	**Port of LB has one cruise berth and it is already SP capable.**
Cruise Terminal	256	0	1	No	Terminal has one berth, with SP already installed.
Berth H4	256	0	1	No	Berth has SP
Los Angeles	**101**	**22**	**6**	**No**	**Port of LA cruise terminal can plug vessels into SP at both berths at the same time.**
World Cruise Terminal	101	22	6	**No**	Terminal has two active berths, with SP already installed at both berths. Can plug two vessels in at the same time.
Berth 92	27	22	4	No	Berth has two 11 kV AMP vault connections and two 6.6 kV vault connections.
Berth 93A	74		2	No	Berth has two 11 kV AMP vault connections.
One berth used 83 days of the year, two berths used at same time 15 days of the year (in 2017)					
San Diego	**89**	**16**	**3**	**No**	**Port of San Diego can plug in one cruise vessel at a time. Assumption is that Port of San Diego will not install additional power to plug in multiple vessels simultaneously, but that assumption may change if updated information is recieved from the Port.**
B Street Pier	81	16	2	No	Port has two terminals B Street (5 berths, with two SP connection points) and Broadway (2 berths, with one SP connection point). The port only has enough power to plug in one vessel at a time, either B-Street OR Broadway, but not at both simultaneously.
North Berth (B-1 and B-2)	14 45	16	1	No	B Street Pier has five berths located on the North, South and West sides of the pier, The North and South side each have one shore power connection point (services both berths). Only one cruise vessel is capable of plugging in at the port at a time.
South Berth (B-4 and B-5)	22 0		1		
Broadway Pier	8	0	1	No	This pier already has SP and limited vessel activity.
Broadway Berth	8	0	1	No	Broadway Terminal has one connection point, with limited activity in 2017. Only one cruise vessel is capable of plugging in at the port at a time.
One berth used 71 days of the year, two berths used at same time 11 days of the year, three berths used at same time 2 days of the year (in 2017)					

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	Total # of Cruise Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Existing Vaults	Additional SP Infrastructure Needed?	Reasoning
San Francisco	**81**	**18**	**1**	**Potentially one additional shore power berth**	**Port of San Francisco operates cruise terminals at two Piers - Pier 27 and Pier 35. Pier 27 has SP infrastructure, but Pier 35 does not have SP infrastructure. Staff assumes that the currently unregulated vessels will be outfitted with SP to comply, and that the number of vessels calling multiple berths on the same day will likely increase, which will result in the port needing an additional shore power berth.**
Cruise Terminal	81	18	1	Potentially one additional shore power berth	The cruise terminal has one SP berth currently and staff assumes they will need one additional SP berth at their terminal.
Pier 27	66	18	1	No	Pier 27 has one berth, with a SP vault already installed.
Pier 35 (North and South Berths)	15		None	Potentially one additional shore power berth	Pier 35 has two berths (north and south), and is typically used as an overflow berth. Pier 35 does not have any SP infrastructure.
One berth used 78 days of the year, two berths used at same time 14 days of the year (in 2017)					

	Total # of Cruise Visits in 2017	# of Anticipated Newly Regulated Vessel Visits	# of Existing Vaults	Additional SP Infrastructure Needed?
Statewide #'s	**527**	**56**	**11**	**1 potential new shore power installation**

1 CARB staff assume SP will be control technology pathway for each cruise terminal. No C+C assumed for cruise vessels.

2 Pier 35 is only cruise berth at a currently regulated Port without any SP infrastructure installed.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	# of Ro-Ro Visits in 2017	# of Frequent Ro Ro Vessels Visiting Terminals in 2017	# of Visits by Frequent Ro Ro Vessels in 2017	Estimated # of C+C Systems Needed	Assumed Control Technology	Improvements to Existing Infrastructure Needed?	Reasoning
Carquinez	**122**	**5**	**24**	**1**	**1 Barge-based C+C (shared)**	**No**	**Barge-based C+C seems most feasible option for Benicia terminal considering minimal space on wharf and implementation date of 2025. CARB staff anticipate terminal being able to share one C+C system, with some operational adjustments.**
Benicia - AM Ports	122	5	24	1			Barge-based C+C seems most cost effective option.
Berth 2	115	5	24	1	Barge-based C+C	No	Comment letter from Benicia Port Terminal Company expressed concern that a land-side C+C system would restrict cargo movement and a barge-based system may not be feasible due to strong currents and navigational hazards. SF Bar Pilots commented they have no significant concerns about a barge-based C+C system being used here, as long as the system is designed with the strong currents in mind.
Berth 3	7	0	0		Barge-based C+C	No	This berth seems primarily used for overflow ro-ro visits.

One berth used 105 days of the year, two berths used at same time 3 days of the year (in 2017)

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	# of Ro-Ro Visits in 2017	# of Frequent Ro Ro Vessels Visiting Terminals in 2017	# of Visits by Frequent Ro Ro Vessels in 2017	Estimated # of C+C Systems Needed	Assumed Control Technology	Improvements to Existing Infrastructure Needed?	Reasoning
Hueneme	**240**	**5**	**21**	**1**	**SP already installed, 1 Land-based C+C**	**No**	**Hueneme already has three SP berths at Wharf 1 for plugging in regulated reefer vessels. Land-based C+C at main ro-ro berth with operational changes at overflow berths may be most cost effective option considering visit activity.**
Wharf 1	19	0	0	0		No	SP already installed at this terminal.
Berth 1	4	0	0	0	SP already installed	No	These berth are primarily used for reefer vessels and overflow ro-ro visits, and already have SP installed.
Berth 2	15	0	0		SP already installed	No	
Wharf 2	212	4	16	1	Land-based C+C	No	This berth is the primary ro-ro berth. Port staff advised there is no room for a barge-based C+C system due to space constraints. Port has expressed concerns with using a capture and control bonnet connection due to diurnal windy conditions that run perpendicular to the bonnet sock.
Berth 4	212	4	16	1	Land-based C+C	No	This berth is the primary ro-ro berth. Port staff advised there is no room for a barge-based C+C system due to space constraints. Port has expressed concerns with using a capture and control bonnet connection due to diurnal windy conditions that run perpendicular to the bonnet sock.
Wharf 3	9	1	5	0		No	Berth 6 is used for overflow ro-ro visits. It does not have the space constraints of berths 1,2, and 4, but is operated by Hueneme through a joint-use agreement with the Navy. CARB staff would like to discuss if operational changes can be made to absorb visits at another berth with controls.
Berth 6 (Navy Joint-Use)	9	1	5	0	Operational changes may be most cost effective?	No	Berth 6 is used for overflow ro-ro visits. It does not have the space constraints of berths 1,2, and 4, but is operated by Hueneme through a joint-use agreement with the Navy. CARB staff would like to discuss if operational changes can be made to absorb visits at another berth with controls.

One berth used 213 days of the year, two berths used at same time 31 days of the year, three berths used at same time 2 days of the year (in 2017)

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	# of Ro-Ro Visits in 2017	# of Frequent Ro Ro Vessels Visiting Terminals in 2017	# of Visits by Frequent Ro Ro Vessels in 2017	Estimated # of C+C Systems Needed	Assumed Control Technology	Improvements to Existing Infrastructure Needed?	Reasoning
Long Beach	**211**	**7**	**36**	**2**	**1 Barge-based C+C (shared), 1 Land-based C+C**	**No**	**Barge-based C+C systems with minor operational changes; Jacobson Pilots at POLB expressed concern about using a barge-based C+C at Berth 83.**
Cooper T. Smith	47	0	0	1 (shared with Crescent Terminal)	Barge-based C+C	No	Jacobson Pilots at POLB did not express any significant concern about using a barge-based C+C system at this berth. Assuming shared barge-based C+C most feasible for flexibilty and cost effectiveness.
Berth F204	3	0	0	1 (shared)	Barge-based C+C	No	Jacobson Pilots at POLB did not express any significant concern about using a barge-based C+C system at this berth.
Berth F205	44	0	0	1 (shared)	Barge-based C+C	No	Jacobson Pilots at POLB did not express any significant concern about using a barge-based C+C system at this berth.
Crescent Terminal	60	0	0	1 (shared with Cooper Terminal)	Barge-based C+C	No	Jacobson Pilots at POLB did not express any significant concern about using a barge-based C+C system at this berth. Assuming shared barge-based C+C most feasible for flexibilty and cost effectiveness.
Berth F207	60	0	0	1 (shared)	Barge-based C+C	No	Jacobson Pilots at POLB did not express any significant concern about using a barge-based C+C system at this berth.
One berth used at F205 and F207 at same time 98 days of the year, two berths used at same time 15 days of the year							
Toyota Logistics	104	7	36	1	Land-based C+C	No	Jacobson Pilots at POLB stated a barge-based C+C system here would block navigational access to the back of the channel for other vessels. A land-based C+C system appears to fit on the berth basis visual maps; port or terminal staff have not advised any wharf infrastructure improvements would be necessary to support weight of land-based C+C system.
Berth B83	104	7	36	1	Land-based C+C	No	Jacobson Pilots at POLB stated a barge-based C+C system here would block navigational access to the back of the channel for other vessels. A land-based C+C system appears to fit on the berth basis visual maps; port or terminal staff have not advised any wharf infrastructure improvements would be necessary to support weight of land-based C+C system.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	# of Ro-Ro Visits in 2017	# of Frequent Ro Ro Vessels Visiting Terminals in 2017	# of Visits by Frequent Ro Ro Vessels in 2017	Estimated # of C+C Systems Needed	Assumed Control Technology	Improvements to Existing Infrastructure Needed?	Reasoning
Los Angeles	**94**	**7**	**54**	**1**	**1 Barge-based C+C (shared)**	**No**	**No significant concern from Los Angeles Pilots about use of a barge-based C+C system. Assuming shared barge-based C+C most feasible for flexibilty and cost effectiveness. Multiple berths only used a few times a year on any given day, anticipate terminal to be able to address this overlap with operational changes.**
WWL	94	7	54	1	Barge-based C+C	No	No significant concern from Los Angeles Pilots about use of a barge-based C+C system at this terminal.
Berth 196	1	0	0	1 (shared)	Barge-based C+C	No	No significant concern from Los Angeles Pilots about use of a barge-based C+C system here.
Berth 197	8	1	7		Barge-based C+C		
Berth 198	69	5	32		Barge-based C+C		
Berth 199	16	1	15		Barge-based C+C		
One berth used 128 days of the year, two berths used at same time 2 days of the year (in 2017)							
Richmond	**71**	**1**	**5**	**1**	**1 Barge-based C+C (shared)**	**No**	**Conversation with SF Bar Pilots did not raise any significant concerns about a barge-based C+C system being used for ro-ro terminal at Richmond. Assuming shared barge-based C+C most feasible for flexibilty and cost effectiveness.**
Auto Warehouse Co.	71	1	5	1	Barge-based C+C	No	Conversation with SF Bar Pilots did not raise any significant concerns about a barge-based C+C system being used at this terminal.
Berth RCH8	71	1	5	1	Barge-based C+C	No	Conversation with SF Bar Pilots did not raise any significant concerns about a barge-based C+C system being used at this berth.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	# of Ro-Ro Visits in 2017	# of Frequent Ro Ro Vessels Visiting Terminals in 2017	# of Visits by Frequent Ro Ro Vessels in 2017	Estimated # of C+C Systems Needed	Assumed Control Technology	Improvements to Existing Infrastructure Needed?	Reasoning
San Diego	**253**	**4**	**36**	**2**	**1 Barge-based C+C (shared), 1 Land-based C+C**	**No**	**Based on port maps, a barge-based C+C system looks to fit at berths 24-2, 24-4, and 24-5 with no navigational concerns. Port staff advised that due to channel restrictions, barge-based C+C was not feasible for berths 24-10 and 24-11. Land-based C+C looks feasible at these berths. Unknown if any wharf infrastructure improvements would be necessary to support weight of C+C system.**
National City Marine	253	4	36	2	1 Barge-based C+C (shared), 1 Land-based C+C	No	Based on port maps, a barge-based C+C system looks to fit at berths 24-2, 24-4, and 24-5 with no navigational concerns. Port staff advised that due to channel restrictions, barge-based C+C was not feasible for berths 24-10 and 24-11. Land-based C+C looks feasible at these berths. CARB staff have not received any information suggesting wharf improvements are needed to support the weight of land-based system at this time.
Berth 24-2	26	1	23	1 (shared)	Barge-based C+C	No	Based on port maps, a barge-based C+C system looks to fit at berths 24-2, 24-4, 24-5 without navigational concerns. Land-based C+C looks like it may possibly fit on the berth, but assuming shared barge-based C+C most feasible for flexibilty and cost effectiveness.
Berth 24-4	19	0	0		Barge-based C+C		
Berth 24-5	156	3	13		Barge-based C+C		
Berth 24-10	23	0	0	1 (shared mobile)	Land-based C+C		Based on port maps and conversation with Port staff, a land-based system seems most feasible due to narrow channel causing possible navigational concerns for a barge-based C+C
Berth 24-11	29	0	0		Land-based C+C		
One berth used 177 days of the year, two berths used at same time 73 days of the year, three berths used at same time 7 days of the year (in 2017)							
San Francisco	**26**	**0**	**0**	**1**	**1 Barge-based C+C (shared)**	**No**	**Per Port staff, barge or land-based C+C system seems feasible, but port is confirming with SF Bar Pilots and engineering staff.**
Pasha Terminal	26	0	0	1	1 Barge-based C+C (shared)	No	Growth to 50-70 vessel visits is expected in 2019, so have included this terminal in our updated berth analysis. Per Port staff, barge or land-based C+C system seems feasible, but port is confirming with SF Bar Pilots.
Pier 80*	26	0	0	1	Barge-based C+C	No	Per Port staff, barge or land-based C+C system seems feasible, but port is confirming with SF Bar Pilots.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	# of Ro-Ro Visits in 2017	# of Frequent Ro Ro Vessels Visiting Terminals in 2017	# of Visits by Frequent Ro Ro Vessels in 2017	Estimated # of C+C Systems Needed	Assumed Control Technology	Improvements to Existing Infrastructure Needed?	Reasoning

Port/Terminal/Berth	# of Ro-Ro Visits in 2017	Estimated # of C+C Systems Needed	Assumed Control Technology	Additional Infrastructure Improvements Needed?
Statewide #'s	1017	9	6 Barge-based C+C, 3 Land-based C+C	No Infrastructure Improvements Assumed

*Port staff advise vessel activity expected to exceed threshold in 2019

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Carquinez	**241**	**7**	**58**	**5 Land-based C+C, 12 cranes**	**Yes**	
Pacific Atlantic	41	3	24	1 Land-based C+C, 2 cranes	Yes	
Berth MRZ 6	41	3	24	2 cranes	Yes	Per SF Bar pilots, a barge-based C+C system would present navigational concerns at this location due to interaction with vessels passing close by under the nearby UPRR bridge. CARB staff analysis of satellite imagery indicates there may be available space for an land-based C+C system in the facility's parking lot. If unable to place system on land, wharf improvements may be necessary to support the weight of a C+C system and piping. Adapting a land-based C+C system and crane will have to account for the wetlands surrounding the pipelines on all sides as it extends from the berth to the treatment facility further inland.
Shell	53	0	0	1 Land-based C+C, 4 cranes	Yes	
Berth MRZ 2	23	0	0	2 cranes	Yes	Although SF Bar Pilots did not have any significant navigational concerns about using a barge-based C+C system at these berths, Shell terminal staff have voiced concerns about using the barge due to mooring line interference. Staff assumes that the berths will likely require structural wharf reinforcements to be able to accomodate piping for tranfersing exhuast gas. CARB staff saw during a field visit to this terminal that a thermal oxidizer facilty used for treating VOC emissions is located onshore (off the berth) and assumes a land-based emissions treatment facility could potentially be located near this thermal oxidizer, and that onshore pipings connecting to each capture bonnet can be both routed to the same treatment destination.
Berth MRZ 3	30	0	0	2 cranes	Yes	
One berth used 128 days of the year, two berths used at same time 15 days of the year (in 2017)						

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth		# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Tesoro - Avon		53	1	4	1 Land-based C+C, 2 cranes	Yes	
	Berth MRZ 5	53	1	4	2 cranes	Yes	Per SF Bar pilots, a barge-based C+C system would present navigational concerns at this location due to interaction with vessels passing close by under the nearby UPRR bridge. CARB staff analysis indicates a potential need for berth reinforcement if a land-based C+C system is used, in order to run additional piping onshore. CARB staff analysis also indicates there may be room for the emissions treatment facility on the western side of the facility.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth		# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Tesoro - Amorco		41	2	11	1 Land-based C+C, 2 cranes	Yes	
	Berth MRZ 8	41	2	11	2 cranes	Yes	Per SF Bar pilots, a barge-based C+C system would present navigational concerns at this location due to the proximity to the Federal Channel. CARB staff analysis of satellite imagery indicates a potential need for berth reinforcement if a land-based C+C system is used, in order to run additional piping onshore. CARB staff analsysis also indicates possible space for the emissions treatment facility to be located on a concrete inland wharf at the edge of a lagoon near the berth; pipelines at this berth cross over a long stretch of wetlands, similar to MRZ 6.
Valero		53	1	19	1 Land-based C+C, 2 cranes	Yes	
	Berth BNC 4	53	1	19	2 cranes	Yes	SF Bar Pilots did not have any significant navigational concerns about using a barge-based C+C system at this BNC 4 given the distance from the Federal Channel. However, terminal staff have raised express safety concerns for using a barge due to weather and strong currents typically affecting vessels tied to this berth . CARB staff analysis of satellite imagery indicates a potential need for berth reinforcement if a land-based C+C system is used to accomadate the additional piping. The piping lines are routed over a set of adjacent railway tracks running paraleel to the shore, the exhaust piping will have to travel the same path. CARB staff analysis also indicates possible locations for the onshore emissions treatment facility may be the parking lot adjacent to the Carquinez bridge.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth		# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Long Beach		**359**	**16**	**115**	**4 Land-based C+C, 7 cranes**	**Yes**	**CARB staff assuming land-based C+C due to safety concerns about barge tying up to a tanker vessel. Jacobson Pilots expressed navigation concern about using a barge-based C+C at Tesoro - Pier B and Tesoro - Pier T; no navigational concerns expressed by harbor pilots at Chemoil or Vopak.**
Chemoil		43	1	7	1 Land-based C+C, 1 crane	Yes	Jacobson Pilots advised there is room for a barge-based system navigationally at this location, however, CARB staff assuming land-based C+C due to industry preference considering safety concerns about barge tying up to a tanker vessel.
	Berth F209	43	1	7	1 crane	Yes	Jacobson Pilots advised there is room for a barge-based system navigationally at this location, however, CARB staff assuming land-based C+C due to industry preference considering safety concerns about barge tying up to a tanker vessel.
Tesoro - Pier B		155	6	44	2 Land-based C+C, 5 cranes	Yes	Jacobson Pilots at POLB stated using a barge-based C+C system at any berth at Pier B would block navigational access to the channel. Per POLA staff, Pier B is not one a contiguous reinforced structure. Two land-based C+C would likely be needed to cover all berths, as they are not in the same physical location (one at berths B77-B78, one at Berths B84-B86)
	Berth B77	14	1	4	1 crane	Yes	Jacobson Pilots at POLB stated using a barge-based C+C system at any berth at Pier B would block navigational access to the channel. Per POLA staff, Pier B is not one a contiguous reinforced structure. Two land-based C+C would likely be needed to cover all berths, as they are
	Berth B78	46	3	16	1 crane	Yes	
	Berth B84	10	0	0	1 crane	Yes	
	Berth B84A	54	1	18	1 crane	Yes	
	Berth B86	31	1	6	1 crane	Yes	

One berth used 185 days of the year, two berths used at same time 97 days of the year, three berths used at same time 20 days of the year (in 2017)

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth		# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Tesoro - Pier T		161	9	64	1 Land-based C+C, 1 crane	Yes	
	Berth T121	161	9	64	1 crane	Yes	Berth already has SP, but likely to need a C+C system for majority of visits from non-SP capable vessels, as industry has expressed a lack of desire for installing SP connections on tanker vessels. Jacobson Pilots stated using a barge-based C+C system at Pier T would block navigational access to the channel. Therefore, staff assumed a land-based C+C system and a crane would be best suited for this terminal.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Los Angeles	**187**	**3**	**18**	**5 Land-based C+C, 6 cranes**	**Yes**	**CARB staff assuming land-based C+C due to safety concerns about barge tying up to a tanker vessel. LA Pilots expressed navigation concern about using a barge-based C+C at PBF Energy and Phillips 66 terminals; no navigational concerns at Shell, Valero, or Vopak.**
PBF Energy	20	2	14	1 Land-based C+C, 1 crane	N/A	N/A - Berth will be demolished
Berth 238 (To Be Upgraded)	20	2	14	1 crane	N/A	Per LA Pilots, there are wave interaction concerns with using a barge-based C+C system at this berth. Staff assumed a land-based C+C system and crane would be best suited for the terminal.
Phillips 66	32	1	4	1 Land-based C+C, 1 crane	o (already upgrading)	
Berth 149 (To Be Demolished)	32	1	4	N/A	N/A	Per LA Pilots, there are wave interaction concerns with using a barge-based C+C system at this berth. Staff assumed a land-based C+C system and crane would be best suited for the terminal. POLA staff advised that berth 149 will be left in place as a non-oil vessel i.e. barge servicing reinforced berth and construction of a new oil terminal is proposed for Berth 151 after demolition of the existing 150-151 berth.
Berth 151 (To Be Upgraded)	Assume similar visit count as Berth 149 after it is demolished	---	---	1 crane	No (already upgrading)	
Shell	38	0	0	1 Land-based C+C, 1 crane	o (already upgrading)	
Berth 168	1	0	0	N/A	N/A	LA Pilots advised there is room for a barge-based system navigationally at this location, however, CARB staff assuming land-based C+C and crane due to industry preference considering safety concerns about barge tying up to a tanker vessel. Per POLA staff, Berth 168 will be demolished and replaced with a new MOTEMS-compliant terminal while the tenant operates at the existing Berth 169. Once Berth 169 is finished and operational, the tenant will move all of their operations to Berth 168 and berth 169 will be demolished.
Berth 169	37	0	0	1 crane	No (already upgrading)	
One berth used 155 days of the year, two berths used at same time 2 days of the year (in 2017)						

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Valero	24	0	0	1 Land-based C+C, 1 crane	o (already upgrading)	
Berth 164	24	0	0	1 crane	No (already upgrading)	LA Pilots advised there is room for a barge-based system navigationally at this location, however, CARB staff assuming land-based C+C and crane due to industry preference considering safety concerns about barge tying up to a tanker vessel. Per POLA staff the berth will be replaced with a MOTEMS compliant structure.
Vopak	73	0	0	1 Land-based C+C, 2 cranes	Yes	
Berth 187	18	0	0	1 crane	Yes	LA Pilots advised there is room for a barge-based system navigationally at this berth, however, CARB staff
Berth 189	55	0	0	1 crane	Yes	
One berth used 215 days of the year, two berths used at same time 30 days of the year (in 2017)						

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Richmond	**391**	**15**	**215**	**4 Land-based C+C, 14 cranes**	**Yes**	
BP/ARCO	40	2	39	1 Land-based C+C, 2 cranes	Yes	
Berth RCH 9	40	2	39	2 cranes	Yes	SF Bar Pilots did not have any significant navigational concerns about using a barge-based C+C system at this berth location, however CARB staff assuming land-based C+C due to terminal's concerns about barge tying up to a tanker vessel at this berth. Staff assumed a land-based C+C and crane is employed, and that the berth would probably have to be structurally reinforced. CARB staff's analysis of satellite imagery shows the parking lot south of the main building structure adjacent to the berth may be a suitable location for an onshore emissions treatment facility.
Chevron - Richmond Long Wharf	283	12	160	1 Land-based C+C, 8 cranes	Yes	
Berth RLW 1	45	1	7	2 cranes	Yes	SF Bar Pilots did not have any significant navigational concerns about using a barge-based C+C system at this berth location, however, Chevron-specific docking pilots did express concern about weather and wave interaction from passing vessels, increasing vessel traffic congestion if barges are used, and the ability to disembark the vessel within 30 minutes. For this analysis, CARB staff are assuming land-based C+C due to the docking pilot's and terminal's concerns about barge tying up to a tanker vessel at this berth. Staff made the assumption that two cranes would be needed per berth rather than one, based on a comment letter from Chevron (dated March 8, 2019) advising staff that two cranes may be needed at each berth at the long wharf to provide flexibility when vessels dock.
Berth RLW 2	67	2	18	2 cranes	Yes	
Berth RLW 3	38	2	18	2 cranes	Yes	
Berth RLW 4	133	7	117	2 cranes	Yes	
One berth used 111 days of the year, two berths used at same time 147 days of the year, three berths used at same time 74 days of the year, four berths used at same time 15 days of the ye						

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Phillips 66/Kinder Morgan	38	0	0	1 Land-based C+C, 2 cranes	Yes	
Berth RCH 11	38	0	0	2 cranes	Yes	SF Bar Pilots did not indicate any significant navigational concerns about using a barge-based C+C system at this berth. Terminal staff raised concerns about RCH 11 using the barge strategy, since one of the berths is dedicated as a berthing spot for barges while the other berth is for ocean-going tanker vessels. CARB staff analysis of satellite imagery indicates that if a land-based C+C system is used, the available room to place the onshore emissions treatment facilty may either be the space between the berth and the tank farm or west past the tank farm, and that the berth itself may need to be reinforced to accomodate for the additional piping.
Pacific Atlantic	30	1	16	1 Land-based C+C, 2 cranes	Yes	
Berth RCH 22	30	1	16	2 cranes	Yes	SF Bar Pilots indicated the channel that the berth faces is too narrow for barge-based C+C system. Basis CARB staff analysis of satellite imagery, the berth may have to be reinforced to be able to handle the additional piping needed for a land-based C+C, and the parking lot behind the warehouse adjacent to the berth (or part of the warehouse itself) could potentially be used to site the onshore emissions treatment facility.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth		# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Rodeo		**108**	**1**	**4**	**2 Land-based C+C, 6 cranes**	**Yes**	
Phillips 66 - Oleum		85	0	0	1 Land-based C+C, 4 cranes	Yes	
	Berth ROD 3	85	0	0	2 cranes	Yes	SF Bar Pilots have raised concerns that barge-based C+C systems would present a navigational risk for this terminal. CARB staff's analysis of satellite maps of the berth indicate there may be room on the berth to run additional pipings to the shore if a land-based C+C and cranes are used. CARB staff analysis also indicates potential shoreside space for the onshore emissions treatment facility may be available if it is situated west of the roadway connecting the shore to the berth.
	Berth ROD 4		0	0	2 cranes	Yes	
One berth used 108 days of the year, two berths used at same time 12 days of the year (in 2017)							
NuStar - Selby		23	1	4	1 Land-based C+C, 2 cranes	Yes	
	Berth ROD 8	23	1	4	2 cranes	Yes	SF Bar Pilots indicated barge-based C+C systems would present a navigational risk for this terminal. CARB staff's analysis of satellite maps of the onshore infrastructure for ROD 8 indicates there is sufficient space for an onshore emissions treatment facility. CARB staff analysis also indicates that the berth may need reinforcing in order to accomodate the additional piping and crane.

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies

8/1/2019

Port/Terminal/Berth	# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning
Stockton	**34**	**1**	**7**	**1 Land-based C+C, 2 cranes**	**No**	**CARB staff is still in the process of the Port evaluation.**
Stockton Port Authority	34	1	7	1 Land-based C+C, 2 cranes	No	
Berth SCK 7-8	34	1	7	2 cranes		SF Bar Pilots did not indicate any significant navigational concerns about using a barge-based C+C at this berth.
One berth used 131 days of the year, two berths used at same time 23 days of the year, three berths used at same time 2 days of the year (in 2017)						

Berth Level CARB Staff Analysis of Potential Emission Reduction Strategies
8/1/2019

Port/Terminal/Berth	# of Tanker Visits in 2017	# of Frequent Tanker Vessels Visiting Terminal in 2017	# of Visits by Frequent Tanker Vessels in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed	Additional Infrastructure Improvements Needed?	Reasoning

Port/Terminal/Berth	# of Tanker Visits in 2017	Assumed Control Technology & Estimated # of C+C Systems Needed
Statewide #'s	**1320**	**21 Land-based C+C, 47 cranes**

*CARB staff made the assumption that all tanker terminals will use a land-based capture and control (C+C system) due to safety concerns industry has expressed with having a barge-based

**CARB staff made assumption that all tanker terminals using a land-based C+C will use a centralized exhaust gas treatment system that is installed on available land space on the terminal,

***CARB Staff made the following assumptions for selecting a bonnet capture system that will direct exhaust gas onshore for treatment

1. Sending the auxiliary engine/boiler exhaust to an onshore situated treatment facility (instead of located on the berth) would not violate the intrinsic concerns raised by industry of situating a high energy/explosion risk near the vessel. This would also reduce the footprint requirements of expanding the berth to accomodate for the additional exhaust conduit. In addition, a single onshore treatment facility can service multiple exhaust streams originating from several berths.

2. CARB staff assumes that terminals with more than one berth would route the emissions from each bonnet to a single, appropriately scaled emissions treatment facility onshore.

3. Even though CARB staff assumes the bonnet capture system with a crane will be the most likely control option for tankers, this does not preclude the terminals or vessels from

APPENDIX D

Proposed Control Measure for Ocean-Going Vessels At Berth

Development of Cost Impacts to Individuals for Standardized Regulatory Impact Assessment

Revised: 8/1/2019

This document was prepared by California Air Resources Board (CARB) Staff to document the methodology used in the development of cost impacts to individuals resulting from the Proposed Control Measure for Ocean-Going Vessels At Berth (Proposed Regulation).

Staff developed the cost impacts to individuals 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.

Summary of Cost Ratios

The following table summarizes the calculated costs to individuals based on the projected annualized cost of the Proposed Regulation in 2030 and the total projected throughput of twenty foot equivalent units (TEU) for container and reefer vessels, number of passengers for cruise vessels, number of automobiles for ro-ro vessels, and gallons of refinery products for tanker vessels. The methodologies used to calculate each cost per unit are described below the table.

Vessel Type	Annualized Cost in 2030	Total Units in 2030	Cost per Unit in 2030	Unit
Container/Reefer	$20,233,000	15,590,200	$1.30	TEU
Cruise	$21,149,000	4,031,800	$5.25	Passenger
Ro-Ro	$18,244,000	2,437,300	$7.49	Automobile
Tanker	$214,444,000	27,156,860,144	$0.0079	Gallons

1. Calculation of Cost per TEU for Container and Reefer Vessels

Staff calculated the estimated increased cost per TEU that would occur due to the Proposed Regulation in 2030, using the following methodology.

Staff obtained specific TEU throughputs for the Port of Los Angeles (POLA)[1], Port of Long Beach (POLB)[2], Port of Oakland[3], Port of Hueneme[4] and Port of San Diego[5] through their websites.

Staff used growth factors derived from those used in staff's Emission Inventory for container and reefer vessels (see SRIA Appendix A for more details). The cumulative weighted growth factor for 2030 is 1.55 using base year 2018 and 1.61 using base year 2017. Staff multiplied the actual TEU throughputs for each port by the growth factor for the data baseline year to yield projected imported TEUs from these five ports in 2030.

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[1] Port of Los Angeles Website: "Container Statistics" (latest update June 2019) https://www.portoflosangeles.org/business/statistics/container-statistics

[2] Port of Long Beach Website: "Yearly TEUs" Table (accessed June 2019) http://www.polb.com/economics/stats/yearly_teus.asp

[3] Port of Oakland Website "Facts and Figures" "Download Monthly TEU Data (1997-2018)" Excel File Download Link: (accessed June 2019) https://www.oaklandseaport.com/performance/facts-figures/ https://www.oaklandseaport.com/wp-content/uploads/2019/02/PortOak-Teus-Jul-97-2018.xls

[4] United States Department of Transportation Maritime Administration (MARAD) Website: "Data Statistics" Port Activity - Container Ship Capacities calling at U.S. Container Ports (2016) Excel Download Link (accessed June 2019) https://www.maritime.dot.gov/data-reports/data-statistics/data-statistics

[5] United States Department of Transportation Maritime Administration (MARAD) Website: "Data Statistics" Port Activity - Container Ship Capacities calling at U.S. Container Ports (2016) Excel Download Link (accessed June 2019) https://www.maritime.dot.gov/data-reports/data-statistics/data-statistics

Port	Year	Actual TEU Throughput	Growth Factor	Estimated TEU Throughput 2030
POLA	2018	4,870,582	1.55	7,549,402
POLB	2018	4,097,377	1.55	6,350,934
Oakland	2018	965,552	1.55	1,496,606
Hueneme	2017	57,474	1.61	92,533
San Diego	2017	62,583	1.61	100,759
Total rounded to nearest hundred				15,590,200

Finally, staff divided the costs of the Proposed Regulation in 2030 by the estimated TEU throughput in 2030 to calculate the estimated cost per TEU.

$20,233,000 / 15,590,200 = $1.30 per TEU in 2030

2. Calculation of Cost per Passenger for Cruise Vessels

Staff calculated the estimated increased cost per cruise vessel passenger that would occur due to the Proposed Regulation in 2030, using the following methodology.

First, staff calculated the average number of cruise vessel passengers per vessel call at POLA passengers using data from 2015, 2016, and 2017, available on the POLA website.[6]

Year	Cruise Vessel Visits at POLA	Total Passengers	Average Passengers per Vessel Call at POLA
2017	109	498,848	4,577
2016	118	602,464	5,106
2015	123	592,335	4,816
2015 through 2017 average, rounded to nearest hundred			4,800

Staff multiplied the average 4,800 passengers per vessel call at POLA to the number of vessel calls at POLA, POLB, Port of San Diego (POSD) and Port of San Francisco (POSF) in 2017 (based on California State Lands Commission data) to estimate the annual total number of passengers visiting cruise terminals that staff expects would be

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[6] Port of Los Angeles Website: “Cruise Statistics” (accessed June 2019)https://www.portoflosangeles.org/business/statistics/cruise-statistics

subject to emission control requirements under the Proposed Regulation (covered terminals).

Port	Number of Cruise Vessel Calls in 2017	Number of Passengers (Calculated)
POLA	101	484,800
POLB	256	1,228,800
POSD	89	427,200
POSF	81	388,800
Total:	527	2,529,600

The number of vessel calls and passengers that made multiple stops to covered terminals in a single voyage was estimated using 2017 CSLC data. In 2017, 100,800 passengers on 21 vessels made multiple stops to covered terminals. This number was subtracted from the total 2,529,600 passengers to estimate the number of unique passengers that visit covered terminals annually.

2,529,600 – 100,800 = 2,428,800 unique passengers per year in 2017

Staff used a compounded growth factor of 1.66, derived from growth factors used in staff's Emission Inventory, to estimate the number of unique passengers that are expected to visit covered terminals in 2030.

2,428,800 x 1.66 = 4,031,800 unique passengers per year in 2030 (rounded to nearest hundred)

Finally, staff divided the costs of the Proposed Regulation in 2030 by the number of passengers in 2030 to calculate the estimated cost per passenger.

$21,149,000 / 4,031,800 = <u>$5.25 per passenger in 2030</u>

3. Calculation of Cost per Auto for Ro-Ro Vessels

Staff calculated the estimated increased cost per automobile that would occur due to the Proposed Regulation in 2030, using the following methodology.

First, staff calculated the average throughput of automobiles (including imports and exports) for 2017 and 2018 at POLA available on their website[7] and POLB received from an email dated May 10, 2019.[8]

Year	Automobiles Imported + Exported

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[7] Port of Los Angeles Website: "The Port of Los Angeles Facts and Figures" (accessed on June 2019) https://www.portoflosangeles.org/business/statistics/facts-and-figures

[8] Email between Morgan Caswell (Port of Long Beach) and Lynsay Carmichael (CARB) dated May 10, 2019.

	POLA	POLB
2017	236,956	307,553
2018	156,091	313,226
Average	196,524	310,390

Then, staff identified automobile throughput numbers for the Port of Richmond and the Port of Hueneme using data obtained from their websites.[9,10] The Port of Richmond's website did not state the data year, so staff assumes that it is a recent year. The Port of Hueneme's data is from fiscal year 2014 – 2015. Staff divided the automobile throughputs for each port by the number of vessel visits in 2017 (CSLC data) to calculate the average number of automobiles per vessel visit.

Port/Terminal	Automobiles per Year	Vessel Visits in 2017	Automobiles per Vessel Visit (Calculated)
Richmond	150,000	71	2,113
Hueneme	321,000	240	1,338
POLA	196,524	94	2,091
POLB	310,390	211	1,471
Average			1,753

Staff then multiplied the calculated average number of automobiles per vessel visit, 1,753, by the number of ro-ro vessel visits reported in 2017 for other ports and terminals to estimate the average throughput of automobiles per year for all covered terminals statewide.

Port/Terminal	Vessel Visits in 2017	Automobiles per Vessel Visit	Automobiles per Year
Richmond	71	2,113	150,000
Hueneme	240	1,338	321,000
POLA	94	2,091	196,524
POLB	211	1,471	310,390
POSD	253	1,753	443,503
Carquinez	122	1,753	213,863
POSF	26	1,753	45,577
Statewide total rounded to nearest hundred			1,680,900

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[9] Port of Richmond Website: "Port of Richmond Auto Facilities" (accessed on June 2019) https://www.transdevelopment.com/?project=richmond

[10] Port of Hueneme Website: "Port Of Hueneme – Port Cargo Numbers Point to Another Record Year" (accessed on June 2019) https://www.portofhueneme.org/port-cargo-numbers-point-to-another-record-year/

Staff used a compounded growth factor of 1.45, derived from growth factors used in staff's Emission Inventory, to estimate the automobile throughput at covered terminals in 2030.

1,680,900 x 1.45 = 2,437,300 automobiles per year in 2030 (rounded to nearest hundred)

Finally, staff divided the costs of the Proposed Regulation in 2030 by the number of automobiles in 2030 to calculate the estimated cost per automobile.

$18,244,000 / 2,437,300 = $7.49 per automobile in 2030

4. Calculation of Cost Gallon of Gasoline for Tanker Vessels:

Staff calculated the estimated increased cost per gallon of refinery product that would occur due to the Proposed Regulation in 2030. This analysis assumes that the total annualized cost from the Proposed Regulation for the tanker industry would be spread over the total volume of product refined in California, which includes compliant gasoline, conventional gasoline, reformulated blendstock for oxygenate blending (RBOB) gasoline, CARB diesel, EPA Diesel, "other" diesel, commercial jet fuel, military jet fuel, and other products, derived from crude oil from all major import sources (marine vessels, pipeline, and truck/rail).

First, staff obtained the total crude oil imports from all sources including marine vessels, pipeline sources, and truck and rail sources in thousands of barrels per day (TBD) in 2016 from California Energy Commission data.

Staff then applied a compounded growth factor of 1.1172 to the marine vessel imports only, derived from growth factors used in staff's Emission Inventory, to estimate total marine vessel crude oil imports from marine vessels in 2030. Staff assumed that the crude oil imports from non-marine vessel sources would remain constant through 2030.

Crude Oil Import Source	Thousand barrels per day in 2016 (TBD)*	Growth Factor	Projected TBD in 2030 (Calculated)
Marine Vessels - Foreign	901.5	1.1172	1,007.2
Marine Vessels - Alaska	185.4	1.1172	207.1
California Source Via Pipelines	550.8	1	550.8
Rail/Truck	6.4	1	6.4
Total:			1,771.5

*Source: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=151596 page 31[11]

Staff then estimated the quantity of refinery products that would be derived from the total crude imports in 2030.

1,771.5 TBD x 42,000 gallons/barrel x 365 days per year = 27,156,860,144 gallons of refinery products in 2030

Finally, staff divided the costs of the Proposed Regulation in 2030 by the number of gallons in 2030 to calculate the estimated cost per gallon of product.

$ 214,444,000 / 27,156,860,144 = $0.0079 per gallon of product in 2030

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[11] California Energy Commission "California Refinery Crude Oil Sources and Trends" Presentation by Gordon Schremp on November 15, 2017. CARB staff pulled the statistics from slide 31 of presentation and put into a table.

APPENDIX E

Proposed Control Measure for Ocean-Going Vessels At Berth

Cost Analysis Equations for Standardized Regulatory Impact Assessment

8/1/2019

This document was prepared by California Air Resources Board (CARB) Staff to document equations used in the development of cost estimates for the Proposed Control Measure for Ocean-Going Vessels At Berth (Proposed Regulation).

Staff developed 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.

I. Barge-Based Capture and Control Costs – Container/Reefer and RoRo Vessels

Costs in non-italicized text are included in the total calculated cost of the Draft Regulation.

Staff assumes costs in italicized text are incurred by the capture and control technology provider, who would then recover costs by charging an hourly fee to the vessel operator for utilization of barge-based systems.

Calculated Value	**Equation**
Hourly Costs	Annual Vessel Visits Utilizing Barges [#] x Emission Control Duration per Visit [hours (hr)] x Hourly Fee [$/hr] x [1 + Compounded Growth Factor [fraction]]
Annualized Capital Costs of Emission Control Systems	*# Barges [#] x Capital Cost per Barge [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]] (Note: After 10 years, cost is multiplied by factor of 50 percent to account for additional repairs and replacement of parts.)*
CARB Technology Approval Costs	*Cost per Approval [$] x Σ{# Approvals [#] x [1 + Compounded Growth Factor [fraction]]}, vessel type*
Annual Performance Testing	*Annual Performance Testing Cost [$] x Σ{# Barges [#] x [1 + Compounded Growth Factor [fraction]]}, vessel type*
Labor Costs	*Labor Cost per Barge [$/hr] x Σ{Annual Vessel Visits [#] x Vessel Visit Duration [hr] x [1 + Compounded Growth Factor [fraction]]}, vessel type*
Fuel Costs	*Fuel Cost per Barge [$/hr] x Σ{Annual Vessel Visits [#] x Vessel Visit Duration [hr] x [1 + Compounded Growth Factor [fraction]]}, vessel type*
Tug Costs	*Tug Cost [$/hr] x Tug-Hours per Vessel Visit [hr] x Σ{Annual Vessel Visits [#] x [1 + Compounded Growth Factor [fraction]]}, vessel type*
Spacer Barge Costs	*Spacer Barge Cost [$/day] x Σ{Annual Vessel Visits [#] x Vessel Visit Duration [hr] / 24 [hr/day] x [1 + Compounded Growth Factor [fraction]]}, vessel type*
Maintenance Costs	*Annual Maintenance Cost per Barge [$] x Σ{# Barges [#] x [1 + Compounded Growth Factor [fraction]]}, vessel type*
Water Recycling Costs	*Annual Water Recycling Cost per Barge [$] x Σ{# Barges [#] x [1 + Compounded Growth Factor [fraction]]}, vessel type*
Barge Leasing/Port Fees	*Number of Barges in Operation [#] x Monthly Leasing/Port Fee [$] 12 months/year x [1 + Compounded Growth Factor [fraction]]*
Barge Overhead Costs	*Number of Barges in Operation [#] x Annual Overhead Costs x [1 + Compounded Growth Factor [fraction]]*

II. Land-Based Capture and Control Costs – RoRo Vessels

Costs in non-italicized text are included in the total calculated cost of the Draft Regulation.

Staff assumes costs in italicized text are incurred by the capture and control technology provider, who would then recover costs through the sale of land-based emission control systems to ports or terminal operators.

Calculated Value	**Equation**
Annualized Capital Costs of Emission Control Systems	Land-Based Emission Treatment Systems [#] x Land-Based Emission Treatment System Cost [$] x [1 + Compounded Growth Factor [fraction]] x Capital Recovery Factor [fraction]
Annual Performance Testing Costs	Land-Based Emission Treatment Systems [#] x Annual Performance Testing Cost per System [$] x [1 + Compounded Growth Factor [fraction]
Annual Labor Costs	Annual Vessel Visits [#] x Emission Control Duration per Visit [hr] x [1 + Compounded Growth Factor [fraction]] x Hourly Labor Cost per System [$]
Annual Maintenance Costs	Land-Based Emission Treatment Systems [#] x Annual Maintenance Cost per System [$] x [1 + Compounded Growth Factor [fraction]
Annual Operational Costs	Annual Vessel Visits [#] x Emission Control Duration per Visit [hr] x Hourly Operating Costs [$/hr] x [1 + Compounded Growth Factor [fraction]]
CARB Technology Approval Costs	*Cost per Approval [$] x Σ[# Approvals [#] x [1 + Compounded Growth Factor [fraction]]], vessel type*

III. Land-Based Capture and Control Costs – Tanker Vessels

Costs in non-italicized text are included in the total calculated cost of the Draft Regulation.

Staff assumes costs in italicized text are incurred by the capture and control technology provider, who would then recover costs through the sale of land-based emission control systems to ports or terminal operators.

Calculated Value	**Equation**
Annualized Capital Costs of: • Emission Control Systems • Terminal Infrastructure (Emission Control System connections, electrical, foundation, etc.) • Berth-to-Emission Control System Piping • Cranes • Crane Support Structures	Number of Berths with Land-Based Emission Control Systems [#] x Component Cost per Berth [$] x [1 + Compounded Growth Factor [fraction]] x Capital Recovery Factor [fraction]
Annual Labor Costs	Number of Berths with Land-Based Emission Control Systems [#] x Annual Labor Cost Per Berth [$] x [1 + Compounded Growth Factor [fraction]]
Annual Maintenance Costs	Number of Berths with Land-Based Emission Control Systems [#] x Annual Maintenance Cost per Berth [$] x [1 + Compounded Growth Factor [fraction]]
Annual Operating Costs	Annual Vessel Visits [#] x Emission Control Duration per Visit [hr] x Hourly Operating Costs [$/hr] x [1 + Compounded Growth Factor [fraction]]
Annualized Feasibility Study Costs	Cost per Berth [$] x Number of Berths [#] /7 years
Annualized Engineering Costs	Cost per Berth [$] x Number of Berths [#] /7 years
Annualized Permitting Costs	Cost per Berth [$] x Number of Berths [#] /7 years
Annual Performance Testing Costs	Land-Based Emission Treatment Systems [#] x Annual Performance Testing Cost per System [$] x [1 + Compounded Growth Factor [fraction]]
CARB Technology Approval Costs	*Cost per Approval [$] x Σ{# Approvals [#] x [1 + Compounded Growth Factor [fraction]]}, vessel type*

IV. Shore Power Berth Retrofit Costs

Calculated Value	Equation
Annualized Shore Power Berth Retrofit Capital Costs – Incurred by Ports	Σ {Shore Power Berth Retrofits [#] x % capital cost incurred by port [%]},port x Capital Cost per Berth Retrofit [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]]
Annualized Shore Power Berth Retrofit Capital Costs – Incurred by Terminals	Σ {Shore Power Berth Retrofits [#] x % capital cost incurred by terminal [%]},port x Capital Cost per Berth Retrofit [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]]
Annual Maintenance Costs – Incurred by Ports	Σ {Shore Power Berth Retrofits [#] x % maintenance cost incurred by port [%]},port x Capital Cost per Berth Retrofit [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]]
Annual Maintenance Costs – Incurred by Terminals	Σ {Shore Power Berth Retrofits [#] x % maintenance cost incurred by terminal [%]},port x Capital Cost per Berth Retrofit [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]]
Annualized Shore Power Vault Capital Costs – Incurred by Ports	Σ {Shore Power Vaults [#] x % capital cost incurred by port [%]},port x Capital Cost per Shore Power Vault [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]]
Annualized Shore Power Vault Capital Costs – Incurred by Terminals	Σ {Shore Power Vaults [#] x % capital cost incurred by terminals [%]},port x Capital Cost per Shore Power Vault [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]]
Annualized Terminal Cable Reel Costs	Σ {Terminal Cable Reels [#] x % capital cost incurred by terminal [%]},port x Capital Cost per Terminal Cable Reel [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]]

V. Shore Power Vessel Retrofit Costs

Calculated Value	Equation
Annualized Shore Power Vessel Retrofit Capital Costs	Vessels to be Retrofit [#] x Cost per Retrofit [$] x Capital Recovery Factor [fraction] x [1 + Compounded Growth Factor [fraction]]
Annual Maintenance Costs	Vessels to be Retrofit [#] x Annual Maintenance Cost [$] x [1 + Compounded Growth Factor [fraction]]

VI. Shore Power Labor and Energy Costs

Calculated Value	Equation
Annual Shore Power Electricity Costs	Annual Vessel Visits [#] x Auxiliary Engine Effective Power [kilowatts (kW)] x Shore Power Connection Duration [hr] x Electricity Price [$/kW-hr] x [1 + Compounded Growth Factor [fraction]]
Annual Shore Power Labor Costs – Incurred by Ports	Σ {Annual Vessel Visits [#] x % Capital Cost Incurred by Port [%]},port x Shore Power Connection Cost per Visit [$] x [1 + Compounded Growth Factor [fraction]]
Annual Shore Power Labor Costs – Incurred by Terminals	Σ {Annual Vessel Visits [#] x % Capital Cost Incurred by Terminal [%]},port x Shore Power Connection Cost per Visit [$] x [1 + Compounded Growth Factor [fraction]]
Annual Shore Power Fuel Savings	Annual Vessel Visits [#] x Shore Power Connection Duration [hr] x Aux. Engine Effective Power [kW] x Brake-Specific Fuel Consumption [grams (g)/kW-hr] x Fuel Price [$/ metric ton (MT)] / 10^6 g/MT x [1 + Compounded Growth Factor [fraction]]
Annual Low Carbon Fuel Standard (LCFS) Credit Value	Annual Vessel Visits [#] x Shore Power Connection Duration [hr] x Auxiliary Engine Effective Power [kW] x Electricity Price [$/kW-hr] x Percent Credits Claimed [%] x [1 + Compounded Growth Factor [fraction]]

VII. Administrative Costs

Calculated Value	Equation
Port Plan Costs	Port Plans [#] x Cost per Port Plan [$] x [1 + Compounded Growth Factor [fraction]]
Terminal Plan Costs	Terminal Plans [#] x Cost per Terminal Plan [$] x [1 + Compounded Growth Factor [fraction]]
Terminal Reporting Costs	Vessel Reports [#] x Cost per Vessel Report [$] x [1 + Compounded Growth Factor [fraction]]
Vessel Reporting Costs	Terminal Reports [#] x Cost per Terminal Report [$] x [1 + Compounded Growth Factor [fraction]]
Personnel Costs for CARB and All Other State, Local and Federal Agencies	Σ {Number of Personnel-Years (PY) [#] x Cost per PY [$]}

VIII. Remediation Costs

Calculated Value	**Equation**
Remediation Costs	Annual Vessel Visits Subject to Hourly Remediation Cost [#] x Duration of Visit [hr] x Hourly Fee [$] x [1 + Compounded Growth Factor [fraction]]

APPENDIX F

Proposed Control Measure for Ocean-Going Vessels At Berth

At Berth Macroeconomic Technology Methodology Appendix

8/1/2019

This appendix provides the detailed technical methodology used to estimate the economic impacts of the Proposed Regulation using the REMI model. Benefits and Direct Costs described in Chapter B and C were used as inputs to the REMI model. Additional analysis is performed to apportion these costs or benefits to the California economy, as described in this section.

1. Allocating Vessel Costs to California Industries

Vessels that visit California ports may be domestic or international, and this distinction is important to accurately model economic impacts. The REMI model version used in this analysis includes impacts within California, but does not account for impacts to vessels outside of California or outside of the United States (U.S.). To account for the economic impacts of requirements impacting all vessels visiting California, all compliance costs to vessels are assumed to be passed on to California businesses and industrial operations within California. This is a conservative assumption, because some costs could be passed on to other countries or states, thus not felt by California exclusively.

The compliance costs to vessels were modeled in REMI by increasing production costs for all downstream industries that rely on Water Transportation (NAICS 483) as an intermediate input. The data for this calculation is derived from REMI's Input-Output (IO) table.

An IO table is a matrix that describes the value of capital, labor, and energy, and intermediate inputs that is required to create one dollar of output in a specific industry. The REMI model's IO table describes the value of intermediate inputs needed to create one dollar of output for each industry. For example, the IO table includes the value of water transportation that is needed to produce one dollar of output for each of the 156 industries included in the model. The IO tables value for water transportation is multiplied by the total output for each industry to get the total expenditure on water transportation industry. The sum of all industries gives the total value of water transportation used by all 156 industries, and the relative proportion used by each industry can be calculated. The percentage of water transportation used by each industry based on this methodology is included in Table F1. Each industries' increase in production costs is modeled as the total increase in costs to vessels multiplied by the percentage of water transportation used by the industry.

Table F1: Estimated Proportion of Water Transportation Per Industry

Sector	NAICS Code	Percent of Total
Forestry; Fishing, hunting, trapping	1131, 1132, 114	0.00%
Logging	1133	0.02%
Support activities for agriculture and forestry	115	0.25%
Oil and gas extraction	211	0.05%
Coal mining	2121	0.04%
Metal ore mining	2122	0.05%
Nonmetallic mineral mining and quarrying	2123	0.08%
Support activities for mining	213	0.03%
Electric power generation, transmission, and distribution	2211	0.52%
Natural gas distribution	2212	0.02%
Water, sewage, and other systems	2213	0.04%
Construction	23	9.52%
Sawmills and wood preservation	3211	0.01%
Veneer, plywood, and engineered wood product manufacturing	3212	0.01%
Other wood product manufacturing	3219	0.05%
Clay product and refractory manufacturing	3271	0.09%
Glass and glass product manufacturing	3272	0.12%
Cement and concrete product manufacturing	3273	0.43%
Lime, gypsum and other nonmetallic mineral product manufacturing	3274, 3279	0.49%
Iron and steel mills and ferroalloy manufacturing	3311	0.51%
Steel product manufacturing from purchased steel	3312	0.05%
Alumina and aluminum production and processing	3313	0.04%
Nonferrous metal (except aluminum) production and processing	3314	0.32%
Foundries	3315	0.01%
Forging and stamping	3321	0.04%
Cutlery and handtool manufacturing	3322	0.00%
Architectural and structural metals manufacturing	3323	0.08%
Boiler, tank, and shipping container manufacturing	3324	0.04%
Hardware manufacturing	3325	0.01%
Spring and wire product manufacturing	3326	0.01%
Machine shops; turned product; and screw, nut, and bolt manufacturing	3327	0.06%
Coating, engraving, heat treating, and allied activities	3328	0.08%
Other fabricated metal product manufacturing	3329	0.07%
Agriculture, construction, and mining machinery manufacturing	3331	0.01%
Industrial machinery manufacturing	3332	0.02%
Commercial and service industry machinery manufacturing	3333	0.03%
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	3334	0.02%
Metalworking machinery manufacturing	3335	0.01%
Engine, turbine, power transmission equipment manufacturing	3336	0.03%
Other general purpose machinery manufacturing	3339	0.05%
Computer and peripheral equipment manufacturing	3341	0.01%
Communications equipment manufacturing	3342	0.05%
Audio and video equipment manufacturing	3343	0.00%

Sector	NAICS Code	Percent of Total
Semiconductor and other electronic component manufacturing	3344	0.21%
Navigational, measuring, electromedical, and control instruments manufacturing	3345	0.08%
Manufacturing and reproducing magnetic and optical media	3346	0.00%
Electric lighting equipment manufacturing	3351	0.05%
Household appliance manufacturing	3352	0.01%
Electrical equipment manufacturing	3353	0.05%
Other electrical equipment and component manufacturing	3359	0.16%
Motor vehicle manufacturing	3361	0.03%
Motor vehicle body and trailer manufacturing	3362	0.01%
Motor vehicle parts manufacturing	3363	0.04%
Aerospace product and parts manufacturing	3364	0.27%
Railroad rolling stock manufacturing	3365	0.00%
Ship and boat building	3366	0.00%
Other transportation equipment manufacturing	3369	0.01%
Household and institutional furniture and kitchen cabinet manufacturing	3371	0.06%
Office furniture (including fixtures) manufacturing; Other furniture related product manufacturing	3372, 3379	0.05%
Medical equipment and supplies manufacturing	3391	0.13%
Other miscellaneous manufacturing	3399	0.24%
Animal food manufacturing	3111	4.21%
Grain and oilseed milling	3112	5.77%
Sugar and confectionery product manufacturing	3113	0.28%
Fruit and vegetable preserving and specialty food manufacturing	3114	1.81%
Dairy product manufacturing	3115	0.42%
Animal slaughtering and processing	3116	0.02%
Seafood product preparation and packaging	3117	0.00%
Bakeries and tortilla manufacturing	3118	0.40%
Other food manufacturing	3119	1.34%
Beverage manufacturing	3121	1.67%
Tobacco manufacturing	3122	0.02%
Textile mills and textile product mills	313, 314	0.05%
Apparel manufacturing; Leather and allied product manufacturing	315, 316	0.02%
Pulp, paper, and paperboard mills	3221	0.10%
Converted paper product manufacturing	3222	0.10%
Printing and related support activities	323	0.05%
Petroleum and coal products manufacturing	324	0.19%
Basic chemical manufacturing	3251	3.15%
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	3252	0.21%
Pesticide, fertilizer, and other agricultural chemical manufacturing	3253	1.30%
Pharmaceutical and medicine manufacturing	3254	0.27%
Paint, coating, and adhesive manufacturing	3255	0.41%
Soap, cleaning compound, and toilet preparation manufacturing	3256	0.12%
Other chemical product and preparation manufacturing	3259	0.22%
Plastics product manufacturing	3261	0.15%

Sector	NAICS Code	Percent of Total
Rubber product manufacturing	3262	0.01%
Wholesale trade	42	1.16%
Retail trade	44-45	1.17%
Air transportation*	481	1.13%
Rail transportation	482	0.05%
Water transportation	483	0.26%
Truck transportation	484	1.51%
Couriers and messengers	492	0.54%
Transit and ground passenger transportation	485	0.04%
Pipeline transportation	486	0.00%
Scenic and sightseeing transportation and support activities	487, 488	1.16%
Warehousing and storage	493	0.05%
Newspaper, periodical, book, and directory publishers	5111	0.03%
Software publishers	5112	0.02%
Motion picture, video, and sound recording industries	512	0.13%
Data processing, hosting, related services, and other information services	518, 519	0.13%
Broadcasting (except internet)	515	0.13%
Telecommunications	517	0.03%
Monetary authorities, credit intermediation, and related activities	521, 522	0.23%
Funds, trusts, and other financial vehicles	525	0.03%
Securities, commodity contracts, and other financial investments and related activities	523	0.06%
Insurance carriers	5241	0.00%
Agencies, brokerages, and other insurance related activities	5242	0.02%
Real estate	531	0.77%
Automotive equipment rental and leasing	5321	0.05%
Consumer goods rental and general rental centers	5322, 5323	0.03%
Commercial and industrial machinery and equipment rental and leasing	5324	0.05%
Lessors of nonfinancial intangible assets (except copyrighted works)	533	0.06%
Legal services	5411	0.03%
Accounting, tax preparation, bookkeeping, and payroll services	5412	0.10%
Architectural, engineering, and related services	5413	0.77%
Specialized design services	5414	0.15%
Computer systems design and related services	5415	0.03%
Management, scientific, and technical consulting services	5416	0.23%
Scientific research and development services	5417	31.22%
Advertising and related services	5418	0.28%
Other professional, scientific, and technical services	5419	0.09%
Management of companies and enterprises	55	0.55%
Office administrative services; Facilities support services	5611, 5612	0.05%
Employment services	5613	0.02%
Business support services; Investigation and security services; Other support services	5614, 5616, 5619	0.21%
Travel arrangement and reservation services	5615	0.02%
Services to buildings and dwellings	5617	0.31%
Waste management and remediation services	562	0.17%
Educational services	61	0.78%

Sector	NAICS Code	Percent of Total
Offices of health practitioners	6211-6213	0.42%
Outpatient, laboratory, and other ambulatory care services	6214, 6215, 6219	0.22%
Home health care services	6216	0.03%
Hospitals	622	0.61%
Nursing and residential care facilities	623	0.08%
Individual and family services; Community and vocational rehabilitation services	6241-6243	0.13%
Child day care services	6244	0.05%
Performing arts companies; Promoters of events, and agents and managers	7111, 7113, 7114	0.05%
Spectator sports	7112	0.03%
Independent artists, writers, and performers	7115	0.01%
Museums, historical sites, and similar institutions	712	0.05%
Amusement, gambling, and recreation industries	713	0.18%
Accommodation	721	0.12%
Food services and drinking places	722	1.21%
Automotive repair and maintenance	8111	0.07%
Electronic and precision equipment repair and maintenance	8112	0.02%
Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance	8113	0.04%
Personal and household goods repair and maintenance	8114	0.03%
Personal care services	8121	0.07%
Death care services	8122	0.01%
Drycleaning and laundry services	8123	0.04%
Other personal services	8129	0.09%
Religious organizations; Grantmaking and giving services, and social advocacy organizations	8131-8133	0.05%
Civic, social, professional, and similar organizations	8134, 8139	0.02%

2. Detailed REMI Input Data

a. Baseline Adjustments

The baseline established by REMI is adjusted with the California Department of Finance conforming forecasts. These forecasts include California population figures dated May 2019 and U.S. real GDP and civilian employment growth numbers dated April 2019.

b. Impacts of the Proposed Regulation

i. Shore Power

To comply with the Proposed Regulation, various industries would face costs to install and maintain shore power equipment. The production cost policy variable was used to model shore power equipment and installation costs that are anticipated to result from the proposed regulation. Ports and terminals are categorized under the support activities for transportation sector (NAICS 488). The annual costs for ports and terminals modeled in REMI reflects amortized capital costs and the industry growth factor.

As a result of the Proposed Regulation, there will be increased demand for shore power equipment and for installation of shore power equipment. Data from the Prop. 1B funded berths at the Port of Los Angeles indicate that between 38 to 76 percent of the costs of berth retrofits go towards equipment and 24 to 62 percent of the costs of berth retrofits go towards construction and labor. The modeling assumes that 50 percent of costs borne by terminals for shore power capital goes towards equipment manufacturers and the remaining 50 percent of the costs go towards installation services. Shore power equipment is typically produced outside of California and by companies located outside of California. Therefore the increased demand allocated to equipment is not included in the REMI modeling. The additional demand for installation services at ports and terminals is modeled as an increase in exogenous final demand in the construction industry.

While the costs to ports and terminals are amortized over a long period of time, the induced demand for shore power equipment is concentrated in years where there is a compliance deadline. As a result, the production costs borne by regulated parties are relatively stable, exhibiting mild growth over time. In contrast, industries meeting the demand for shore power equipment and installation see large jumps in demand immediately prior to compliance deadlines.

In addition to capital and installation costs, ports and terminals will face increases in costs associated with maintenance. Due to the high voltage nature of shore power equipment and safety concerns, maintenance is anticipated to be provided by manufacturers of the shore power equipment. Maintenance that is provided by equipment manufacturers is modeled as an increased production cost to the support activities for transportation industry and an increase in exogenous final demand for the electrical equipment manufacturing industry.

Additional labor that is provided by ports and terminals is modeled as a decrease in labor productivity. Labor productivity is defined as an industries output divided by employment. To estimate the change in labor productivity, the increased cost of labor was translated into its implied increased employment using REMI's baseline employment and compensation values. The implied increase in employment and REMI's baseline output is used to recalculate labor productivity under the Proposed Regulation. The percentage change in labor productivity is input into REMI's labor productivity policy variable for the support activities for transportation industry.

Vessels will also need to install and maintain shore power equipment. As described in Section 1 of this appendix, these costs are modeled as production cost increases to all California industries that rely on water transportation as an intermediate input. The CARB Vessel survey data indicates that on average, 50 percent of the costs for vessel retrofits were capital costs, while 25 percent went towards installation costs and another 25 percent went toward other costs.

Additional shore power vessel retrofits will result in increases in demand for industries providing shore power equipment and installation services. Shore power equipment is typically manufactured by companies outside of California and by companies located outside California. In addition, the retrofits for many vessels are anticipated to occur outside of California and have no impact on the California economy. As a conservative assumption, Staff assume that for Jones Act vessels, 50 percent of the berth retrofit capital costs could be mirrored as an increase in exogenous final demand in the ship and boat building industry (NAICS 3366) to reflect potential increases in vessel installations that may occur within California.[1] Similar to terminal and port maintenance costs, maintenance is assumed to be provided by shore power manufacturers.

When vessels utilize shore power at California ports, save on fuel. The savings associated with fuel use for vessels are modeled as changes in the production cost for all industries that utilize water transportation as an intermediate input as described in Section 1 of this appendix. Ports and terminals will bear the immediate costs of increased electricity use due to shore power activity. The costs associated with electricity use for shore power is modeled as changes in the production costs for the support activities for transportation industry. Changes in electricity and fuel demand are modeled as changes in exogenous final demand in the electric power generation, transmission, and distribution industry and changes in exogenous final demand in the petroleum and coal products manufacturing industry. Additional per visit labor costs to ports and terminals to comply with the Proposed Regulation are modeled as decreases in labor productivity for the support activities for transportation industry.

LCFS credits are generated as a result of using shore power equipment. Terminal operators, as the owners of the fueling supply equipment (shore power equipment) will be the ones to generate the LCFS credits.[2] As a result, the value of the LCFS is modeled as a decrease in production costs for the terminal operators in the support activities for transportation industry.

ii. Capture and Control

Barge Based Capture and Control

There is anticipated to be an increase in demand for barged based capture and control services as a result of the Proposed Regulation. In order to meet demand, barge operators are expected to make investments in capture and control technology and barges. Costs to barge operators are modeled as an increase in production costs in the support activities for transportation industry. The capture and control technology and barges themselves are anticipated to be manufactured out of state, and therefore are not reflected modeled as increasing demand in any California industry.

To comply with the Proposed Regulation, developers of capture and control technology must have their technology approved and tested. Costs associated with testing and applications are modeled as an increased production cost to the ventilation, heating, air-conditioning, and commercial refrigeration equipment industry. The demand for third party testing is modeled as an increase in exogenous final demand to the architectural, engineering, and related services industry and fees to CARB for testing and approval is modeled as an increase in state government spending.

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[1] Jones Act vessels are constructed in the United States, registered under the U.S., owned by U.S. citizens, and crewed by U.S. citizens and U.S. permanent residents. This assumption excludes costs that would likely occur outside of the U.S., but also accounts for some costs that would have occurred outside of California, but still in the U.S.

[2] 95483(c)(6)(A) https://www.arb.ca.gov/regact/2018/lcfs18/fro.pdf

To recoup the costs of their investments, barge operators are anticipated to charge an hourly fee to vessels that utilize their services. The increased costs to vessels is modeled as an increase in production costs to all industries that use water transportation as an intermediate input, as described in Section 1 of this appendix. The increased revenue for barge operators is modeled as an increase in industry sales to the support activities for transportation industry.

Land Based Capture and Control

As described in Chapter A.1.e, several vessel categories are anticipated to comply by using land based capture and control, instead of barge based capture and control. Terminals will face costs to install and maintain land based capture and control equipment and vessel operators will face ongoing costs to operate the capture and control equipment.

The costs to terminals for feasibility studies, engineering costs, permitting costs, performance testing, demurrage costs, capture and control infrastructure, and installation are all modeled as an increase in production costs to the support activities for transportation industry.

The equipment used in the land based capture and control systems is expected to be manufactured out of state and is not reflected as an increase in demand for any California industries. However, 50 percent of the costs for emissions control systems, emissions control system support structures, berth-to-shore piping, cranes, crane support structures, and terminal infrastructure and electric utility infrastructure costs are anticipated to be related to construction. This portion of the costs to terminals is mirrored as an increase in exogenous final demand to the construction industry.

Performance testing, feasibility studies, engineering, and permitting is expected to be performed on site and the costs to that are borne by terminals are also mirrored as an increase in exogenous final demand to the architectural, engineering, and related services industry. Finally, fees to CARB for technology testing and approval are modeled in REMI as an increase in government spending.

iii. Other Costs and Benefits of the Proposed Regulation

The Proposed Regulation imposes requirements for planning and reporting. Costs to ports and terminals for planning are modeled as increases in production costs to the support activities for transportation industry and an increase in exogenous final demand in the architectural, engineering, and related services industry. Reporting and planning costs borne by terminals are modeled as an increase in production costs the support activities for transportation industry, reporting costs for vessel operators are modeled as an increase in production costs in industries that use water transportation as an intermediate input, and these costs are also reflected as increases in exogenous final demand in the office administrative services industry.

CARB, CSLC, federal and local agencies are anticipated to require additional staffing to implement the Proposed Regulation. The state and local government employment policy variable is used to model the additional employment needed at these state and local government agencies. The state and local government spending variable is used to reflect the differences in compensation between these new employees and REMI's default compensation for state and local government employees. Similarly, the civilian federal government employment policy variable is used to model the additional employment needed for federal agencies, and the civilian federal government spending variable is used to reflect the differences in compensation between these new employees and REMI's default compensation rate for federal employees.

The decrease in acute respiratory, cardiovascular, and asthma related hospital and emergency room visits result in less household spending in the healthcare industry. This decrease in consumer spending allows for an increase in all other consumption categories. This is modeled as a decrease in consumer spending on hospitals which is then reallocated amongst the consumers' typical bundle of purchases.

To provide flexibility for terminals and vessels, the Proposed Regulation allows for certain exemptions for emissions reductions. Some of these result in a remediation fee. Remediation fees paid by terminals are modeled as an increase in production costs to the support activities for transportation industry, and remediation fees paid by vessels are modeled as an increase in production costs for all industries that utilize water transportation as an intermediate input. The remediation fee is used for additional emissions reduction programs and is modeled in REMI as an increase in local government spending in the year it is assessed.

c. REMI Inputs

Tables G2 and G3 present the specific inputs used in REMI for modeling the Proposed Regulation. Costs were adjusted from 2019 dollars to 2016 dollars when input into the REMI model.

Table F2: REMI Inputs for Proposed Regulation

REMI Variable	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Production Cost - Scenic and sightseeing transportation and support activities for transportation (487, 488) – million 2016$	22.04	26.5	52.46	53.03	98.48	106.3	196.3	187.9	190.2	172.9	174.9	177.5	180.3
Production Cost - Petroleum and coal products manufacturing (324) – million 2016$	0	0.21	0.21	0.45	0.46	0.46	0.48	0.5	0.52	0.55	0.57	0.61	0.64
Labor Productivity - Scenic and sightseeing transportation and support activities for transportation (487, 488) – percent change	0	0	0	0	0	0	0	-0.01	-0.01	-0.02	-0.02	-0.03	-0.03
Exogenous Final Demand - Architectural, engineering, and related services (5413) – million 2016$	13.49	13.95	38.65	38.21	38.24	38.5	38.49	25.16	25.18	0.71	0.7	0.71	0.72
Exogenous Final Demand - Office administrative services; Facilities support services (5611, 5612) – million 2016$	0	0.19	1.81	1.86	1.9	1.95	2.01	2.05	2.09	2.13	2.18	2.23	2.29
Exogenous Final Demand - Electric power generation, transmission, and distribution (2211) – million 2016$	0	0.55	0.56	1.18	1.23	1.29	1.33	1.38	1.43	1.49	1.55	1.62	1.68
Exogenous Final Demand - Petroleum and coal products manufacturing (324) – million 2016$	0	-0.45	-0.49	-1.09	-1.18	-1.28	-1.36	-1.45	-1.55	-1.66	-1.77	-1.9	-2.03
Exogenous Final Demand - Ship and boat building (3366) – million 2016$	4.64	0	0	0	0	0	0	0	0	0	0	0	0
Exogenous Final Demand - Construction (23) – million 2016$	129.7	0	0	0	302.3	0	569.8	0	0	0	0	0	0
Exogenous Final Demand - Electrical equipment manufacturing (3353) – million 2016$	0	0.13	0.13	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19
Industry Sales - Scenic and sightseeing transportation and support activities for transportation (487, 488) – million 2016$	0	2	2.07	2.15	2.23	14.44	14.92	15.35	15.71	16.08	16.46	16.85	17.32

REMI Variable	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Local Government Spending – million 2016$	0	2.2	2.29	2.39	2.48	2.8	2.87	3.8	3.9	4.92	5.03	5.2	5.37
State Government Spending – million 2016$	0.012	-0.53	-0.51	-0.26	-0.25	-0.31	-0.3	-0.29	-0.28	-0.58	-0.57	-0.57	-0.57
Federal Government Spending – million 2016$	0	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
State Government Employment – additional jobs	2	9	9	9	9	9	9	10	10	10	10	10	10
Local Government Employment – additional jobs	0	1	1	1	1	1	1	1	1	1	1	1	1
Federal Government Employment – additional jobs	0	1	1	1	1	1	1	1	1	1	1	1	1
Consumer Spending – Hospitals – million 2016$	0	0.15	0.16	0.2	0.22	0.27	0.29	0.44	0.47	0.54	0.57	0.59	0.55

Table F3: REMI Inputs to Model Costs to Vessel Operators Passed on to California Industries

Production Cost Increase	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Forestry; Fishing, hunting, trapping (1131, 1132, 114)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Logging (1133)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Support activities for agriculture and forestry (115)	0.03	0.04	0.04	0.04	0.04	0.07	0.08	0.09	0.09	0.13	0.14	0.14	0.14
Oil and gas extraction (211)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Coal mining (2121)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
Metal ore mining (2122)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Nonmetallic mineral mining and quarrying (2123)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04
Support activities for mining (213)	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Electric power generation, transmission, and distribution (2211)	0.06	0.08	0.08	0.08	0.09	0.16	0.16	0.19	0.19	0.28	0.28	0.29	0.30
Natural gas distribution (2212)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water, sewage, and other systems (2213)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Construction (23)	1.11	1.43	1.56	1.55	1.60	2.89	3.00	3.50	3.59	5.11	5.21	5.32	5.46
Sawmills and wood preservation (3211)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Veneer, plywood, and engineered wood product manufacturing (3212)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Other wood product manufacturing (3219)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Clay product and refractory manufacturing (3271)	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05
Glass and glass product manufacturing (3272)	0.01	0.02	0.02	0.02	0.02	0.04	0.04	0.05	0.05	0.07	0.07	0.07	0.07
Cement and concrete product manufacturing (3273)	0.05	0.06	0.07	0.07	0.07	0.13	0.14	0.16	0.16	0.23	0.23	0.24	0.25
Lime, gypsum and other nonmetallic mineral product manufacturing (3274, 3279)	0.06	0.07	0.08	0.08	0.08	0.15	0.15	0.18	0.18	0.26	0.27	0.27	0.28

Production Cost Increase	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Iron and steel mills and ferroalloy manufacturing (3311)	0.06	0.08	0.08	0.08	0.09	0.16	0.16	0.19	0.19	0.28	0.28	0.29	0.29
Steel product manufacturing from purchased steel (3312)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
Alumina and aluminum production and processing (3313)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03
Nonferrous metal (except aluminum) production and processing (3314)	0.04	0.05	0.05	0.05	0.05	0.10	0.10	0.12	0.12	0.17	0.17	0.18	0.18
Foundries (3315)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Forging and stamping (3321)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Cutlery and handtool manufacturing (3322)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Architectural and structural metals manufacturing (3323)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04
Boiler, tank, and shipping container manufacturing (3324)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Hardware manufacturing (3325)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spring and wire product manufacturing (3326)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Machine shops; turned product; and screw, nut, and bolt manufacturing (3327)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Coating, engraving, heat treating, and allied activities (3328)	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05
Other fabricated metal product manufacturing (3329)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04
Agriculture, construction, and mining machinery manufacturing (3331)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Industrial machinery manufacturing (3332)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Commercial and service industry machinery manufacturing, including digital camera manufacturing (3333)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing (3334)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Metalworking machinery manufacturing (3335)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01

Production Cost Increase	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Engine, turbine, power transmission equipment manufacturing (3336)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Other general purpose machinery manufacturing (3339)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Computer and peripheral equipment manufacturing, excluding digital camera manufacturing (3341)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Communications equipment manufacturing (3342)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Audio and video equipment manufacturing (3343)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Semiconductor and other electronic component manufacturing (3344)	0.02	0.03	0.03	0.03	0.04	0.06	0.07	0.08	0.08	0.11	0.11	0.12	0.12
Navigational, measuring, electromedical, and control instruments manufacturing (3345)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04
Manufacturing and reproducing magnetic and optical media (3346)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric lighting equipment manufacturing (3351)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03
Household appliance manufacturing (3352)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Electrical equipment manufacturing (3353)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Other electrical equipment and component manufacturing (3359)	0.02	0.02	0.03	0.03	0.03	0.05	0.05	0.06	0.06	0.09	0.09	0.09	0.09
Motor vehicle manufacturing (3361)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Motor vehicle body and trailer manufacturing (3362)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Motor vehicle parts manufacturing (3363)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03
Aerospace product and parts manufacturing (3364)	0.03	0.04	0.04	0.04	0.05	0.08	0.08	0.10	0.10	0.14	0.15	0.15	0.15
Railroad rolling stock manufacturing (3365)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ship and boat building (3366)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other transportation equipment manufacturing (3369)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Household and institutional furniture and kitchen cabinet manufacturing (3371)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03

Production Cost Increase	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Office furniture (including fixtures) manufacturing; Other furniture related product manufacturing (3372, 3379)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Medical equipment and supplies manufacturing (3391)	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.05	0.05	0.07	0.07	0.07	0.07
Other miscellaneous manufacturing (3399)	0.03	0.04	0.04	0.04	0.04	0.07	0.08	0.09	0.09	0.13	0.13	0.14	0.14
Animal food manufacturing (3111)	0.49	0.63	0.69	0.69	0.71	1.28	1.33	1.55	1.59	2.26	2.31	2.35	2.41
Grain and oilseed milling (3112)	0.67	0.87	0.94	0.94	0.97	1.75	1.82	2.12	2.17	3.10	3.16	3.23	3.31
Sugar and confectionery product manufacturing (3113)	0.03	0.04	0.05	0.05	0.05	0.08	0.09	0.10	0.11	0.15	0.15	0.16	0.16
Fruit and vegetable preserving and specialty food manufacturing (3114)	0.21	0.27	0.30	0.30	0.31	0.55	0.57	0.67	0.68	0.97	0.99	1.01	1.04
Dairy product manufacturing (3115)	0.05	0.06	0.07	0.07	0.07	0.13	0.13	0.15	0.16	0.23	0.23	0.23	0.24
Animal slaughtering and processing (3116)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Seafood product preparation and packaging (3117)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bakeries and tortilla manufacturing (3118)	0.05	0.06	0.06	0.06	0.07	0.12	0.12	0.15	0.15	0.21	0.22	0.22	0.23
Other food manufacturing (3119)	0.16	0.20	0.22	0.22	0.23	0.41	0.42	0.49	0.50	0.72	0.73	0.75	0.77
Beverage manufacturing (3121)	0.19	0.25	0.27	0.27	0.28	0.51	0.53	0.61	0.63	0.89	0.91	0.93	0.95
Tobacco manufacturing (3122)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Textile mills and textile product mills (313, 314)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Apparel, leather and allied product manufacturing (315, 316)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Pulp, paper, and paperboard mills (3221)	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.06	0.06	0.06	0.06
Converted paper product manufacturing (3222)	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.06	0.06	0.06
Printing and related support activities (323)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03
Petroleum and coal products manufacturing (324)	0.02	0.03	0.03	0.03	0.03	0.06	0.06	0.07	0.07	0.10	0.10	0.10	0.11

Production Cost Increase	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Basic chemical manufacturing (3251)	0.37	0.47	0.51	0.51	0.53	0.96	0.99	1.16	1.19	1.69	1.72	1.76	1.80
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing (3252)	0.02	0.03	0.03	0.03	0.04	0.06	0.07	0.08	0.08	0.11	0.12	0.12	0.12
Pesticide, fertilizer, and other agricultural chemical manufacturing (3253)	0.15	0.19	0.21	0.21	0.22	0.39	0.41	0.48	0.49	0.70	0.71	0.72	0.74
Pharmaceutical and medicine manufacturing (3254)	0.03	0.04	0.04	0.04	0.05	0.08	0.09	0.10	0.10	0.14	0.15	0.15	0.15
Paint, coating, and adhesive manufacturing (3255)	0.05	0.06	0.07	0.07	0.07	0.13	0.13	0.15	0.16	0.22	0.23	0.23	0.24
Soap, cleaning compound, and toilet preparation manufacturing (3256)	0.01	0.02	0.02	0.02	0.02	0.03	0.04	0.04	0.04	0.06	0.06	0.06	0.07
Other chemical product and preparation manufacturing (3259)	0.03	0.03	0.04	0.04	0.04	0.07	0.07	0.08	0.08	0.12	0.12	0.12	0.13
Plastics product manufacturing (3261)	0.02	0.02	0.03	0.03	0.03	0.05	0.05	0.06	0.06	0.08	0.08	0.09	0.09
Rubber product manufacturing (3262)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Wholesale trade (42)	0.14	0.17	0.19	0.19	0.20	0.35	0.37	0.43	0.44	0.62	0.64	0.65	0.67
Retail trade (44-45)	0.14	0.17	0.19	0.19	0.20	0.35	0.37	0.43	0.44	0.63	0.64	0.65	0.67
Air transportation (481)	0.13	0.17	0.18	0.18	0.19	0.34	0.36	0.41	0.42	0.60	0.62	0.63	0.65
Rail transportation (482)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.03	0.03
Water transportation (483)	0.03	0.04	0.04	0.04	0.04	0.08	0.08	0.10	0.10	0.14	0.14	0.15	0.15
Truck transportation (484)	0.18	0.23	0.25	0.25	0.25	0.46	0.48	0.56	0.57	0.81	0.83	0.84	0.86
Couriers and messengers (492)	0.06	0.08	0.09	0.09	0.09	0.16	0.17	0.20	0.20	0.29	0.29	0.30	0.31
Transit and ground passenger transportation (485)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Pipeline transportation (486)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scenic and sightseeing transportation and support activities for transportation (487, 488)	0.14	0.17	0.19	0.19	0.19	0.35	0.36	0.43	0.44	0.62	0.63	0.65	0.66
Warehousing and storage (493)	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03

Production Cost Increase	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Newspaper, periodical, book, and directory publishers (5111)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
Software publishers (5112)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Motion picture, video, and sound recording industries (512)	0.01	0.02	0.02	0.02	0.02	0.04	0.04	0.05	0.05	0.07	0.07	0.07	0.07
Data processing, hosting, related services, and other information services (518, 519)	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.05	0.05	0.07	0.07	0.07	0.08
Broadcasting (except internet) (515)	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.05	0.05	0.07	0.07	0.07	0.07
Telecommunications (517)	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Monetary authorities, credit intermediation, and related activities (521, 522)	0.03	0.03	0.04	0.04	0.04	0.07	0.07	0.09	0.09	0.12	0.13	0.13	0.13
Funds, trusts, and other financial vehicles (525)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Securities, commodity contracts, and other financial investments and related activities (523)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Insurance carriers (5241)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agencies, brokerages, and other insurance related activities (5242)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Real estate (531)	0.09	0.12	0.13	0.13	0.13	0.23	0.24	0.28	0.29	0.41	0.42	0.43	0.44
Automotive equipment rental and leasing (5321)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Consumer goods rental and general rental centers (5322, 5323)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Commercial and industrial machinery and equipment rental and leasing (5324)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Lessors of nonfinancial intangible assets (except copyrighted works) (533)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Legal services (5411)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Accounting, tax preparation, bookkeeping, and payroll services (5412)	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.06	0.06	0.06	0.06
Architectural, engineering, and related services (5413)	0.09	0.12	0.13	0.13	0.13	0.24	0.24	0.29	0.29	0.42	0.42	0.43	0.44
Specialized design services (5414)	0.02	0.02	0.03	0.03	0.03	0.05	0.05	0.06	0.06	0.08	0.08	0.09	0.09

Production Cost Increase	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Computer systems design and related services (5415)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Management, scientific, and technical consulting services (5416)	0.03	0.04	0.04	0.04	0.04	0.07	0.07	0.09	0.09	0.13	0.13	0.13	0.13
Scientific research and development services (5417)	3.65	4.68	5.10	5.08	5.25	9.47	9.85	11.49	11.75	16.75	17.09	17.44	17.89
Advertising, public relations, and related services (5418)	0.03	0.04	0.05	0.05	0.05	0.09	0.09	0.10	0.11	0.15	0.15	0.16	0.16
Other professional, scientific, and technical services (5419)	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05
Management of companies and enterprises (55)	0.06	0.08	0.09	0.09	0.09	0.17	0.17	0.20	0.21	0.29	0.30	0.31	0.31
Office administrative services; Facilities support services (5611, 5612)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03
Employment services (5613)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Business support services; Investigation and security services; Other support services (5614, 5616, 5619)	0.02	0.03	0.03	0.03	0.04	0.06	0.07	0.08	0.08	0.11	0.12	0.12	0.12
Travel arrangement and reservation services (5615)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Services to buildings and dwellings (5617)	0.04	0.05	0.05	0.05	0.05	0.09	0.10	0.11	0.12	0.17	0.17	0.17	0.18
Waste management and remediation services (562)	0.02	0.03	0.03	0.03	0.03	0.05	0.06	0.06	0.07	0.09	0.10	0.10	0.10
Educational services; private (61)	0.09	0.12	0.13	0.13	0.13	0.24	0.25	0.29	0.29	0.42	0.43	0.44	0.45
Offices of health practitioners (6211-6213)	0.05	0.06	0.07	0.07	0.07	0.13	0.13	0.15	0.16	0.22	0.23	0.23	0.24
Outpatient, laboratory, and other ambulatory care services (6214, 6215, 6219)	0.03	0.03	0.04	0.04	0.04	0.07	0.07	0.08	0.08	0.12	0.12	0.12	0.12
Home health care services (6216)	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Hospitals; private (622)	0.07	0.09	0.10	0.10	0.10	0.18	0.19	0.22	0.23	0.33	0.33	0.34	0.35
Nursing and residential care facilities (623)	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.03	0.03	0.04	0.05	0.05	0.05
Individual and family services; Community and vocational rehabilitation services (6241-6243)	0.01	0.02	0.02	0.02	0.02	0.04	0.04	0.05	0.05	0.07	0.07	0.07	0.07

Production Cost Increase	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Child day care services (6244)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Performing arts companies; Promoters of events, and agents and managers (7111, 7113, 7114)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Spectator sports (7112)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Independent artists, writers, and performers (7115)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Museums, historical sites, and similar institutions (712)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Amusement, gambling, and recreation industries (713)	0.02	0.03	0.03	0.03	0.03	0.06	0.06	0.07	0.07	0.10	0.10	0.10	0.10
Accommodation (721)	0.01	0.02	0.02	0.02	0.02	0.04	0.04	0.04	0.05	0.06	0.07	0.07	0.07
Food services and drinking places (722)	0.14	0.18	0.20	0.20	0.20	0.37	0.38	0.45	0.46	0.65	0.66	0.68	0.70
Automotive repair and maintenance (8111)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04
Electronic and precision equipment repair and maintenance (8112)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Commercial and industrial machinery and equipment (except automotive and electronic) repair and maintenance (8113)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03
Personal and household goods repair and maintenance (8114)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Personal care services (8121)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04
Death care services (8122)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Drycleaning and laundry services (8123)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Other personal services (8129)	0.01	0.01	0.02	0.01	0.02	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.05
Religious organizations; Grantmaking and giving services, and social advocacy organizations (8131-8133)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03
Civic, social, professional, and similar organizations (8134, 8139)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Private households (814)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX G

Draft
Estimating Health Benefits Associated with Reductions in PM and NOx Emissions: Detailed Description

8/1/2019

1. Introduction

CARB uses two different methods to estimate the number of adverse health outcomes, including premature death, related to exposure to particulate matter less than or equal to 2.5 µm in diameter (PM2.5). In most cases, CARB uses the *incidence-per-ton* (IPT) methodology to estimate health outcomes from emissions data. The IPT methodology is a simplified procedure that uses pre-calculated results, obtained by running a mathematical health model on a baseline scenario, to compute estimates of the number of cases of adverse health outcomes. In cases where measured or modeled PM2.5 concentrations are available at a high spatial resolution, CARB staff may input them directly into the health model to obtain estimates of health outcomes. This is referred to as *direct estimation*.

2. Overview of the IPT methodology

CARB uses the IPT methodology to quantify the health benefits of regulations and programs that reduce PM2.5 and precursor emissions. It is based on an approach developed by the U.S. Environmental Protection Agency (EPA), as described by Fann et al. (2009, 2012, 2018). The mathematical relationship between changes in emissions and changes in health outcomes is approximately linear. The IPT methodology is based upon this relationship, and makes the following assumptions:

(1) Changes in health outcomes are proportional to changes in PM concentration;
(2) Changes in primary pollutant concentrations are proportional to changes in emissions; and

(3) Changes in secondary pollutant concentrations are approximately proportional to changes in emissions. It should be noted that there may be cases where the relationship between emission of oxides of nitrogen (NOx) and ammonium nitrate aerosol is not linear.

Due to the approximately linear relationship between premature deaths (or other health outcomes) and emission concentrations, the number of premature deaths can be estimated by multiplying emissions by a scaling factor: the *IPT factor*. IPT factors are developed by applying a health model to measured air pollution concentrations for a baseline period to estimate the number of health outcomes associated with PM2.5 exposure, then dividing by emissions of PM2.5 or a precursor.

Measured or modeled air pollution concentrations, baseline incidence rates, projections of future population size, and a concentration-response function relating changes in PM2.5 exposure to changes in mortality incidence are used to perform calculations. Current IPT factors were developed from a baseline scenario using air quality data, incidence data and emission inventories for 2014-2016, and age-stratified population projections for 2010 through 2060. IPT factors are calculated separately for each air basin.

IPT factors are currently available for two types of PM: diesel particulate matter (DPM) primarily from on-road sources, and secondary ammonium nitrate formed from NOx. Health effects of primary PM2.5 from sources other than on-road diesel engines are estimated by using IPT factors developed for DPM and multiplied by a relative potency factor, as described below.

In addition to premature mortality from cardiopulmonary causes, CARB currently uses IPT factors to estimate hospitalizations due to cardiovascular and respiratory causes and emergency room visits due to asthma.

Since the total incidence of health effects is proportional to population, results for future years are adjusted by the ratio of the projected population in the target year to the average population in the base years 2014-2016.

3. CARB’s health model

CARB’s health model is based on the methodology used by US EPA’s BenMAP benefits mapping and analysis software [US EPA BenMAP]. CARB developed its own health model in order to overcome limitations of BenMAP, primarily to provide the capacity to handle very large data sets, enable automation of repetitive tasks, and facilitate the incorporation of California-specific data. The health model uses a multi-step process to estimate health impacts from measured or modeled PM2.5 concentrations. These steps are described below.

Estimating exposure from measured concentrations

CARB's health model estimates population-weighed exposure to primary and secondary PM2.5 from annual concentrations measured at monitors located throughout California. The mortality quantification method requires estimation of exposure between monitors across a geographic area, not only at points where monitors are located. The model uses a well established spatial interpolation method known as inverse distance-squared weighting. Since PM2.5 is emitted directly from sources (primary PM2.5) and is also formed from gases that convert to PM2.5 through atmospheric chemical processes (secondary PM2.5), separate exposure estimates are made for each:

- **Estimating Diesel particulate matter concentrations**
  Annual diesel particulate matter (DPM) concentrations are not measured directly. Rather, they are estimated indirectly from annual average NOx concentrations by multiplying them by air basin and year-specific DPM/NOx emission ratios computed from CARB emission inventories.

  The methodology and its rationale is described in greater detail in CARB 2010a and Propper et al., 2015. DPM concentrations were estimated at 106 monitors located throughout the state. In order for an annual NOx average to be considered valid, the data were required to be at least 75% complete.

- **Estimating secondary ammonium nitrate concentrations**
  In addition to DPM, CARB computes health impacts for secondary ammonium nitrates PM2.5 formed in the atmosphere from NOx by chemical processes. To estimate ammonium nitrate PM2.5 exposure, CARB staff use speciated PM2.5 nitrate ion (NO_3^-) concentration data from two sources: the air quality monitoring network maintained by CARB and local air quality districts, and the IMPROVE visibility network (IMPROVE Visibility Network).

  CARB and air pollution control districts operate a network of PM2.5 monitors around the state, mostly in urban areas (ARB AQMN). PM2.5 samples are collected as 24-hour filter samples, once every 3-6 days. Samples from some monitors are further analyzed to determine the concentration of nitrate ion and other constituents. During 2014-2016, nitrate data were available from 18 urban monitors. Data for these monitors are retrieved from ARB's ADAM air quality database (ARB ADAM).

In addition to the urban monitors, the national IMPROVE visibility network operated 20 PM2.5 nitrate ion monitor during 2014-2016, mainly in national parks and other remote locations (IMPROVE Visibility Network). These instruments collect one sample every three days. IMPROVE data are retrieved from the project web site (IMPROVE Visibility Network).

Daily samples were aggregated by monitor to obtain annual averages. In order for an annual average to be considered valid, the data were required to be at least 75% complete. To convert from nitrate ion concentration to ammonium nitrate (NH_4NO_3) concentration, the annual averages were multiplied by the ratio of the molecular weight of ammonium nitrate to that of the nitrate ion.

Prior to May, 2019, CARB used PM10 nitrate data instead of more accurate PM2.5 nitrate data to estimate ammonium nitrate aerosol concentrations to compute health impacts. This is because speciated PM10 data was available for more locations than speciated PM2.5, and better reflected the spatial variability in ammonium concentrations across California. However, the number of monitors in the speciated PM10 network has shrunk and is now comparable in size and coverage to the speciated PM2.5 network. Therefore, as of May, 2019, CARB uses PM2.5 nitrate data to compute impacts instead. The PM2.5 nitrate monitors are more accurate because they store the filters in a refrigerated compartment, and less of the sample is lost to volatilization. Consequently, the estimated PM2.5 nitrate concentrations and associated IPT factors for NOx emissions are approximately 50% higher than those used prior to May, 2019.

Estimating exposure using from modeled concentrations

The health model can also be run with concentrations derived from an air quality model as input. Air quality models include dispersion models, which model how pollutants are dispersed by the wind, and photochemical models, which are more elaborate and capture the effects of sunlight, temperature, chemical reactions and other physical processes on pollutants. Dispersion models are only used for primary pollutants, as they are not capable of modeling formation of secondary pollutants. Air quality models generate gridded results, with grid cells typically in the range of 500-2,000m square.

Population projections at the census tract level

CARB's health model uses age-resolved population data at the census tract level, for the 2010 Census, obtained from the U.S. Census Bureau (U.S. Census Bureau). These were projected to 2011-2060 using age-resolved county population projections from the California Department of Finance (CDOF).

Age-specific growth factors for each county, for each year, were computed from the CDOF projections by dividing each county population for the target year by the average county population for the base years 2014-2016. These growth factors were applied to each census tract in the county, for each age group separately. Population was projected 17 five-year age brackets. The age brackets start with ages 0-4 and go up to ages 80-84, plus an additional age bracket for ages 85 and greater.

This method of projection reflects growth in overall county population, but does not model changes in population distribution within counties, such as expansion of urban areas into surrounding rural land.

Estimating baseline incidence

CARB's health model uses incidence data for cardiopulmonary mortality extracted from the Center of Disease Control (CDC) Wonder database. Incidence data for hospitalizations for cardiovascular and respiratory causes, and emergency room visits for asthma are taken from US EPA BenMAP benefits mapping software (US EPA BenMAP).

Baseline incidence rates vary by age bracket. Incidence rates were estimated separately for all 17 five-year age brackets.

Mortality incidence data are county-specific. Incidence data for other health outcomes is uniform throughout California.

Estimating health outcomes using a concentration-response function

CARB's health model estimates the incidence of premature death and other health outcomes at each census tract or modeling grid cell by an equation

$$\text{Incidence} = [\text{population}]_i \times [\text{baseline incidence}]_i \times [\ 1 - \exp(\ -\beta \times \text{PM2.5}\ )\ ]$$

where the subscript *i* indexes the age groups. The incidence is summed over age groups to obtain the total incidence for the census tract. The coefficient β is taken from one of the health studies discussed below.

The specific form of this equation is determined by the type of statistical model used by the health studies to model the relationship between PM2.5 exposure and health risk. All the studies selected by CARB use a so-called log-linear relationship, so all the equation for the incidence takes the form shown above.

CARB draws upon health studies used by the U.S. EPA for its risk assessments (US EPA 2010). CARB uses a subset of the endpoints used by U.S. EPA, chosen on the basis of their strength and robustness. For premature mortality, CARB uses the cardiopulmonary mortality risk coefficient for the 1999-2000 time period from Krewski et al., 2009, among the largest studies of its kind, with 360,000 participants. For cardiovascular and respiratory hospitalizations, CARB used Bell et al., 2008, and for emergency room visits for asthma CARB used Ito et al., 2007.

The process for selecting these studies was described in detail in CARB's 2010 PM2.5 mortality report (CARB 2010b).

Aggregating health outcomes by air basin

To aggregate results from census tracts to larger geographical subdivisions such as counties or air basins, CARB's health model uses a geospatial technique called areal interpolation. Areal interpolation is a procedure for translating spatial data from one set of geographical subdivisions to another when the boundaries do not exactly overlap. Numerous variants of the technique exist, but for the purpose of this analysis the simplest form, which uses area of polygon intersection, was employed (Goodchild and Lam, 1980, Flowerdew and Green, 1994). The precision of this method depends on the size of the geographical subdivisions and the spatial homogeneity of the quantity being apportioned. In urban areas, where census tracts are small and population is distributed more evenly, areal interpolation to larger subdivisions such as air basins yields relatively precise estimates. In rural areas where the population is distributed unevenly over large census tracts, estimates are less precise.

4. Computing IPT factors From health outcomes and emissions

IPT factors are computed separately for each air basin. To compute IPT factors for DPM, the estimates incidence of premature death or other health outcomes associated with DPM exposure for the baseline years is divided by DPM emissions for each air basin. To compute IPT factors for secondary ammonium nitrate, incidence is divided by emissions of the precursor, NOx.

Health benefit calculations using IPT factors

To estimate the reduction in health outcomes associated with reductions in DPM and NOx from a regulation, the change in emissions is multiplied by IPT factor. This value is then multiplied by the ratio of the projected target year population with the 2014-2016 average population to adjust for population growth.

5. Uncertainty in health impact estimates

This methodology is well-established and includes up-to-date information. However, there are uncertainties in the underlying data and assumptions:

- Air quality data is subject to natural variability from meteorological conditions, local activity, etc.
- The assumption that changes in concentrations of pollutants are proportional to changes in emissions of those pollutants or their precursors is an approximation. There may be cases where actual changes in concentrations are higher or lower than predicted.
- The estimation of DPM concentrations and DPM/NOx emission ratios is subject to uncertainty. Emissions are reported at an air basin resolution, and do not capture local variations.
- Inverse distance-squared weighting, the spatial interpolation method is used to estimate concentrations each census tract. Compared with other geospatial estimation methods such as Kriging, inverse distance-squared interpolation has the virtue of simplicity, and does not require selection of parameters. When data are abundant, most simple interpolation techniques give similar results (Jarvis et al., 2001). All geospatial estimation techniques exhibit greater uncertainty when data points are sparser, and uncertainty increases with distance from the nearest data points.
- Future population estimates are subject to increasing uncertainty as they are projected further into the future. For reasons of computational efficiency, the spatial resolution of population estimates is limited to census tract resolution.
- Observed baseline incidence rates change over time, and are subject to random year-to-year variation and systematic shifts as population characteristics and medical treatments evolve. Sample size requirements necessitate estimating baseline incidence rates at large geographic scales, state or county.
- Relative risks in the concentration response function are estimated with uncertainty and reported as confidence ranges.

6. Relative potency factors for non on-road diesel sources

To quantify the health benefits of reductions in primary PM2.5 from sources other than on-road diesel vehicles, CARB uses IPT factors developed for DPM and multiplies the results by a relative potency factor specific to the source and location of the emissions.

Relative potency may be determined in several ways, including but not limited to

- The ratio of the Intake Fraction of the source to the Intake Fraction for DPM. The Intake Fraction is a measure of the fraction of the emissions from a given source that is inhaled by the receptor population. It is specific to a source and a location; e.g., a particular type of facility in a given air basin.
- Comparison of IPT results with direct estimation results for the same scenario. The ratio of the results obtained by the two methods may then be used to adjust the results obtained by IPT factors in a larger setting. For example, the ratio of results obtained by IPT and direct estimation for one air basin may be used to adjust results for other air basins.
- General consideration of conditions under which emissions take place. For example, if an on-road vehicle delivers goods from a facility in a remote location to a facility located in an urban area, half of idling emissions may be considered to occur far from receptor populations. Hence, an adjustment factor of 0.5 may be appropriate for computing the health benefits of reducing idling emissions.

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