Research and Data Gathering of Port Emissions and Reduction Strategies

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This report presents the findings and recommendations of a comprehensive study conducted by the Texas A&M Transportation Institute (TTI) study team on emissions reduction strategies for ports in the United States. The primary objective of the project was to investigate and evaluate various strategies implemented at ports to reduce emissions across the country. The study encompassed incentive/grant programs, voluntary initiatives, and regulatory measures that have proven effective in mitigating port-based emissions.

The research involved a literature review that identified successful emissions reduction measures, which were then quantified to determine their potential environmental impact. To provide decision-makers with valuable insights, the study team also assessed the associated costs, implementation timelines, and potential cost savings for vessel owners and ports. By adopting a holistic approach, this study offers stakeholders a comprehensive understanding of the environmental, economic, and operational benefits associated with different emissions reduction strategies.

Based on the analysis, the TTI study team recommends several key strategies for consideration by the Texas Commission on Environmental Quality (TCEQ). These include:

1. Ocean Going Vessel (OGV) Speed Reduction: The vessel speed reduction proves to be one of the most cost-effective approaches for reducing emissions from OGVs. This program offers the advantage of not requiring equipment upgrades and can provide incentives in the form of rebates or credits. Additionally, encouraging OGV owners to register with the Environmental Ship Index (ESI) program can provide accurate information on participating vessels. Registration fees may pose a challenge, but the port can incentivize cleaner OGVs by offering additional benefits.
2. Shore Power for OGVs at Berth: Transitioning OGVs to shore power during berth operations eliminates emissions from auxiliary engines. While the costs associated with shore power adoption, including construction, retrofitting, and electricity expenses, can be substantial, they are significantly outweighed by the cost benefits. Prioritizing shore power adoption in older vessels (Tiers 0 - II) maximizes emissions reductions, as newer vessels already have lower emissions.

3. Commercial Harbor Craft (CHC) and Cargo Handling Equipment (CHE) Upgrade, Repower, or Replacement: Upgrading or replacing older CHC and CHE in the fleet (Tiers 0 - II) can lead to substantial reductions in emitted pollutants. Ports should focus on replacing port-owned CHCs and offer incentives to tenants for replacing non-port-owned units. Such upgrades can also help offset emissions from other projects.
4. Electrification of CHE: Replacing diesel engines on CHE with electric batteries eliminates engine emissions. While the installation of charging facilities involves a significant investment, selectively replacing diesel engines on CHE with battery-powered alternatives, as demonstrated by the Port of Southern Louisiana's Globalplex Harbor's cranes installation, proves to be highly cost-effective. Identifying the CHE to electrify should consider installation and charging facility costs, as well as potential emission reductions.

To assist with the further evaluation of these recommended strategies, the TTI study team developed an Excel-based tool. The tool enables users to select specific strategies, input preferred parameters, and calculate emission reductions and cost benefits.

1 INTRODUCTION

This chapter provides an in-depth discussion of the background and scope of the study conducted by the TTI to support the TCEQ's efforts in developing emissions inventories for ports in Texas. The TCEQ routinely develops emissions inventories for all ports in Texas as part of their efforts to comply with the United States Environmental Protection Agency's (US EPA) comprehensive triennial emissions reporting requirements and to support the State Implementation Plan (SIP).

The primary objective of this project was to investigate and evaluate various emissions reduction strategies that have been successfully implemented at ports around the US. The literature review conducted as part of this study focused on identifying incentive/grant programs, voluntary programs, and regulatory measures that have been effective in reducing port-based emissions. The findings of the literature review were used to determine the potential emissions reductions that can be achieved through the implementation of these measures.

To provide decision-makers with valuable insights, the TTI study team quantified the potential cost of implementing these measures, the timeline for implementation, and any potential cost savings for vessel owners or ports. By taking a holistic approach to emissions reduction, this project provides stakeholders with a comprehensive understanding of the environmental, economic, and operational benefits associated with various emissions reduction strategies. Ultimately, this study provided recommendations for effective and feasible emissions reduction measures that can be adopted by ports around the US, to reduce the impact of port activities on local air quality and public health while promoting sustainable growth of the maritime industry.

1.1 BACKGROUND

Texas ports are critical to the economic growth of the state and are hubs of international trade. According to recent estimates, the ports in Texas contribute nearly $450 billion to the state's economy and over $1 trillion nationwide [1]. The Texas ports' activities are a crucial part of the state's economy, connecting Texas businesses to markets around the world and supporting jobs and economic opportunities across the state. In 2020, the ports in the Texas maritime system moved more than 607 million tons of cargo; five of the ports within the Texas maritime system, Houston, Corpus Christi, Beaumont, Texas City, and Port Arthur, are within the top 20 U.S. ports by total tonnage [1]. In 2019, the Texas Ports Association reported that the ports supported a total of 5,399,525 jobs

(128,848 of which were direct jobs in Texas) and generated a total of $1.314 trillion in total economic revenues ($53.6 billion of which were direct business revenues) [2]. Figure 1 shows the Texas maritime system, which includes 11 deep draft ports, 8 shallow draft ports, and 2 recreational shallow draft ports along the Texas arm of the Gulf Intracoastal Waterway (GIWW), a 426-mile long inland waterway that runs along the Gulf-Coast of Texas, from Sabine Pass to Brownsville. More information on the individual ports is provided by the Texas Department of Transportation (TxDOT) in their latest (2022) 2024 – 2025 Texas Port Profile document, available here: https://ftp.txdot.gov/pub/txdot-info/mrt/final-port-profiles-2022.pdf [1].

While the port activities generate significant revenue for the state and its residents, the activities also contribute to air pollution in the surrounding areas. At ports, the sources of air pollution include emissions due to mobile sources (marine vessels, rail, trucks, and cargo handling equipment) and stationary sources (refineries, oil or gas storage facilities, and storage of open piles of coal) [3]. Emissions from marine vessels are a major source of greenhouse gases (GHG), carbon dioxide (CO_2), nitrogen oxides (NO_x), sulfur oxides (SO_x), particulate matter (PM), and black carbon [4].

Aside from the marine vessels, on-land sources for NO_x include diesel-operated cargo handling equipment, trucks, and locomotives. In addition, ports are also a source of dust as they handle large amounts of bulk cargo which in dry and windy conditions can result in dust dispersing into the neighboring communities Further, the port-based emissions are difficult to control because of the intertwined operational structure between regulations, shipping operations (both land-use and seaside, presence of both public and private sector operators), and final consumers (industries, suppliers, etc.) [5]. As such, port emissions reduction strategies have become a significant area of concern in recent years as the global community seeks to reduce emissions and improve air quality.

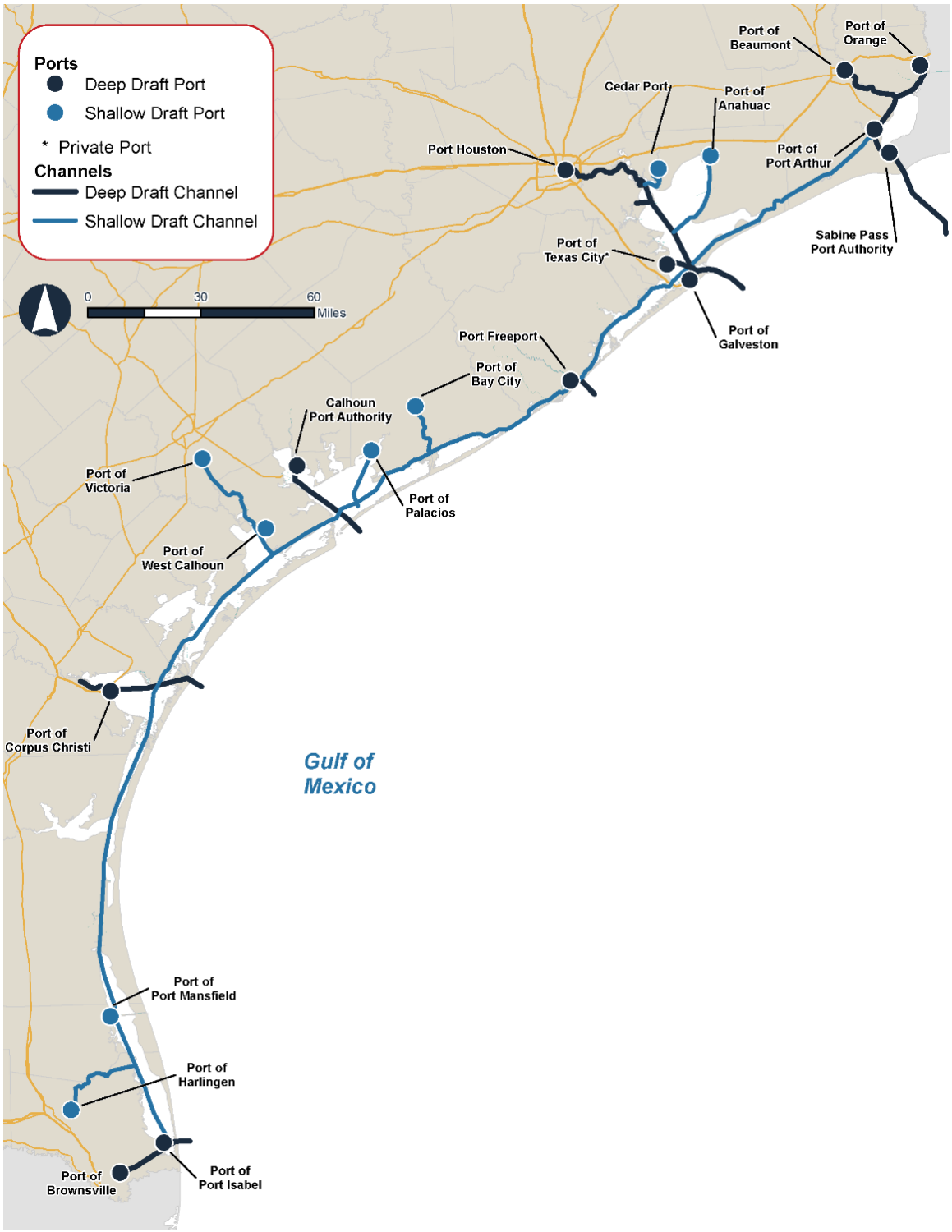


Figure 1. Ports in the state of Texas.

The map is lifted directly from TxDOT's Texas Ports Map, source: https://ftp.txdot.gov/pub/txdot-info/tpp/giww/map_tx_ports.pdf

The National Ambient Air Quality Standards (NAAQS) are set by the EPA to protect public health and the environment by limiting the number of air pollutants in the air [6]. A map of the nonattainment areas in the US is shown in Figure 2. According to the Diesel Technology Forum, 39 of the 360 (about one in nine) commercial ports in the US are located in areas that are in non-attainment for at least one criteria air pollutant according to the NAAQS [7]. Some of the major seaports located in nonattainment areas include the Port of Los Angeles (POLA), the Port of Long Beach (POLB), the Port of Houston (POH), etc. These seaports are responsible for handling a significant portion of the country's international trade and can be a major source of air pollution in their respective regions.

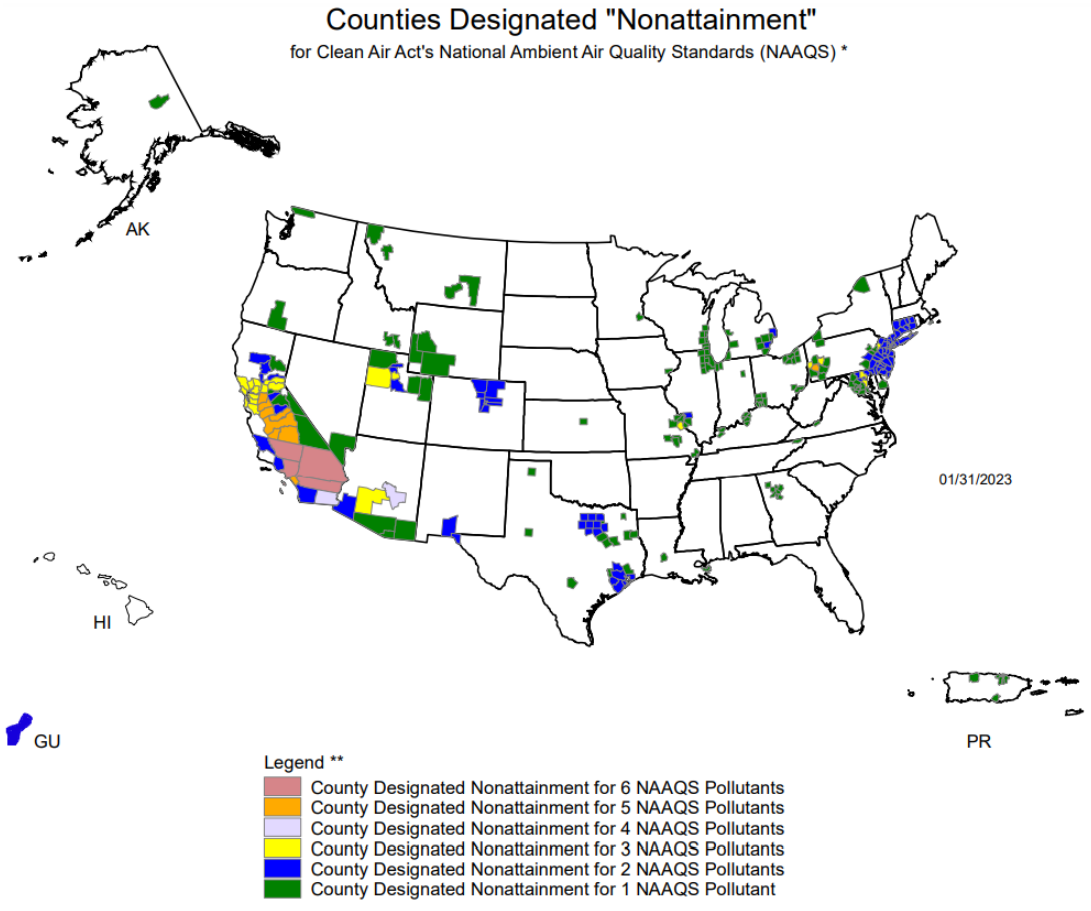


Figure 2. US Counties designated Nonattainment for the NAAQS.

This figure was lifted directly from the EPA's Greenbook, updated on January 31, 2023, and can be found at: https://www3.epa.gov/airquality/greenbook/map/mapnpoll.pdf

*Based on standards for carbon monoxide (CO), lead (Pb) (1978 and 2008), nitrogen dioxide (NO_2), 8-hour ozone (2008), particulate matter under 10 microns (PM_{10}) and 2.5 microns ($PM_{2.5}$) (1997, 2006, and 2012), and sulfur dioxide (SO_2) (1971 and 2010).

**Counties with partial nonattainment status were shown as full counties on the map

1.2 Scope of Study

To reduce the emissions from port-related activities, many national, state, and voluntary emissions reduction programs have been implemented, which include a wide variety of control programs and strategies that aim at reducing criteria air pollutant emissions.

This project aims to investigate various methods for reducing emissions, which includes analyzing incentive/grant programs, voluntary initiatives, and regulatory measures that have been effective at multiple ports. TTI used the data collected to assess the possible range of emissions reduction for the suggested strategies, estimate costs and the timeline to implement them, and determine potential cost savings for ports and vessel owners.

This study included six (6) tasks: Task 1 involved preparing the grant activity description and quality assurance project plan for the study. In Task 2, monthly progress was reported to TCEQ. Task 3 required the preparation of a spreadsheet summarizing identified port emission reduction strategies and their potential emission benefits for TCEQ review and approval. For Task 4, a memo summarizing the survey efforts and information gathered was prepared. Task 5 involved estimating the emission impact and cost-effectiveness of select port strategies and preparing a spreadsheet summarizing the potential emission reduction, implementation timelines, and cost benefits analysis for TCEQ review and approval. Finally, in Task 6, all the work done was compiled into this final project report.

2 LITERATURE REVIEW ON IMPLEMENTED PORT EMISSIONS REDUCTION MEASURES

This chapter discusses the work that the TTI study team performed under **Task 3 - Literature Review on Implemented Port Emissions Reduction Measures**. The TTI study team conducted a thorough literature review to identify port-based emission reduction strategies that were successfully implemented or have been planned at ports across the US. The literature review covers various approaches and technologies that can be implemented to reduce emissions from ports, such as repowering or retrofitting older equipment or vehicles, energy-efficient operations, and shore power. The review drew on existing research and studies to explore successful examples of emissions reduction measures that had been implemented at ports in the US.

The list of port activity data includes but is not limited to the following:

- Port name and geographic information where the strategy is implemented,
- Attainment/nonattainment classification,
- Strategy description, implementation year, sources affected, range of potential emissions reductions, and potential cost-savings benefits,
- Pollutant focus (i.e., ozone, PM, CO), and
- Funding source and requirement

2.1 OVERVIEW OF PORT-BASED EMISSIONS AND PORT EMISSIONS REDUCTION STRATEGIES

This section provides brief summaries of the major sources of port emissions and categories of strategies aimed at reducing these emissions.

2.1.1 Port Emission Sources Categories

The EPA broadly groups port-emission sources into five categories: cargo handling equipment (CHE), commercial harbor craft (CHC), drayage trucks, ocean-going vessels (OGV), and rail facilities [8].

- CHCs are vessels that provide goods and services to ports, including pilot boats, tugboats, and ferries. Examples of CHCs include container ships, bulk carriers, oil tankers, and passenger vessels such as cruise ships and water taxis [9].
- CHE is used to load, unload, and transport cargo at ports. Examples of CHE include cranes, forklifts, trucks, tractors, and conveyors. Emissions from port CHEs are significant contributors to local air quality issues [10].
- Drayage Trucks are an essential component of the intermodal transportation system that moves goods from ports to inland locations[1]. These vehicles contribute significantly to the poor air quality in and around ports due to their high levels of NO_x and PM emissions. The stop-and-go nature of drayage truck operations and long idling times are other factors that exacerbate emissions. [11]
- OGVs are large ships designed for the transportation of goods, cargo, and people across oceans and seas. These ships are typically built for long-distance travel and can range in size from small coastal vessels to large container ships and oil tankers. These vessels are used for a wide range of activities, including international trade, tourism, research, and offshore operations. Examples of OGVs include container ships, bulk carriers, oil tankers, and cruise ships [12].
- Port-based rails are a crucial component of the transportation infrastructure in ports as they provide an efficient means of moving cargo between ships and trains, and thus, play a significant role in ensuring the smooth flow of goods through ports. The diesel-powered locomotives used in port-based rails emit harmful pollutants, including NO_x and PM [13].

2.1.2 Emission Reduction Strategy Categories

This study broadly categorizes emissions reduction strategies into the following categories:

- **Rules and Regulatory measures:** Regulatory measures refer to policies and regulations put in place to decrease the level of emissions produced by ports and maritime activities. These measures aim to minimize the adverse effects of port-based emissions on the environment and public health by promoting the

[1] For this study, TTI combined drayage trucks and other on-road vehicles used in port-related operations under the umbrella of "On-Road Vehicle".

adoption of cleaner practices, fuels, and technology. These measures are regulated and enforced by regulatory authorities such as the International Maritime Organization (IMO), the US EPA, and local governments. The most common regulatory measures include setting emission standards, creating emission control areas (ECA), and providing incentives for ships that use cleaner fuels or technologies. At the port-level, the ports can mandate or encourage their tenants to adopt cleaner practices or to use cleaner technology. To facilitate port emission reduction efforts, the ports can also monitor and report on emissions, develop an emissions inventory (EI), and develop targets and action plans to reduce emissions over time.

- **Incentive and grant programs:** Incentive and grant programs aim to promote the adoption of environmentally friendly practices and technologies that reduces emissions by providing financial or other benefits to ports and shipping companies. These programs reduce the financial burden on ports and shipping companies and promote investment in new technologies. Grant programs can provide funding for a range of activities, including the development and implementation of clean energy and alternative fuel technologies, installation of shore power infrastructure, retrofitting of vessels to reduce emissions, and research and development of new technologies. Incentive programs also include tax credits, rebates, or reduced fees for environmental compliance.
- **Alternative fuel:** Heavy fuels like diesel and bunker fuel are commonly used by vessels, but they release significant emissions when burnt. Alternative fuels such as liquefied natural gas (LNG) and hydrogen are cleaner and more sustainable fuels compared to heavy fuels. According to a study by the US Department of Energy's Maritime Administration (MARAD), the switch from diesel to LNG can lead to significant reductions in PM and NO_x emissions, up to 93% and 92%, respectively, in marine vessels [14]. However, despite these benefits, significant improvements in infrastructure and technology are still necessary to make alternative fuels a viable option. For example, the use of LNG requires specialized infrastructure for storage and delivery [15].
- **Shore power:** Ships typically rely on their auxiliary engines to power onboard systems such as lighting and air conditioning when they are moored at ports. To mitigate the emission released by the ship’s auxiliary engine while at berth, many ports are turning to shore power, which involves connecting the vessel directly to the local power grid instead of using their engines. While many ports are

transitioning to shore power, it is not yet available at all ports due to the high cost of installing the necessary infrastructure on both the ship and at the port. In Texas, while most ports do not currently use shore power, it's important to note that shore power is used at the Port of Beaumont and Port of Galveston for their MARAD Ready Reserve fleets and Texas A&M training vessels, respectively [16].

- **Repower, retrofit, or replacing:** Replacing older vehicles and equipment with cleaner alternatives is a viable approach to minimize emissions from port operations. Port equipment and vehicles typically use diesel engines; replacing them with cleaner alternatives, like electric or hybrid models, or upgrading older engines with newer and cleaner ones, can significantly reduce emissions emitted from these sources. For example, Tier 4 engines, which were phased in starting in 2008, can further reduce PM and NO_x emissions by 90% compared to Tiers 1 through 3 engines [17].
    - Examples of strategies to reduce emissions from port-emission sources from the EPA's *National Port Strategy Assessment: Reducing Air Pollution and Greenhouse Gases at U.S. Ports* report are listed in Table 1 below.

Table 1. Examples of Emission Reduction Strategies for Port-Emission Sources.

Sources	Strategy description
Drayage Trucks	Replace older diesel trucks with trucks that meet cleaner EPA standards and/or plug-in hybrid electric vehicles.
Rail Facilities	1. Replace older line-haul locomotive engines with cleaner technologies, including electric locomotives. 2. Improve fuel economy. 3. Replace older switcher locomotive engines with cleaner technologies and Generator Set (GenSet) technology.
CHE	Replace older yard trucks, cranes, and container handling equipment with cleaner technologies, including electric technologies.
CHC	Replace or repower older tugs and ferries with cleaner technologies, including hybrid electric vessels.
OGV	1. Switch to lower sulfur fuel levels that are below EPA's regulatory standards, and LNG for certain vessel types. 2. Utilize shore power to reduce the hoteling of the container, passenger, and reefer vessels. 3. Apply Advanced Marine Emission Control Systems for container and tanker vessels.

The executive summary of EPA's National Port Strategy Assessment: Reducing Air Pollution and Greenhouse Gases at U.S. Ports report is available here: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100PGT0.pdf [18]

- The EPA also summarized the potential emission reductions from these strategies, as listed in Table 2.

Table 2. Example of Percent Reduction in NO_x and $PM_{2.5}$ from Port Strategies in the "Business as Usual" Scenario.

Emission Reduction Strategies	NO_x		$PM_{2.5}$	
	2020	2030	2020	2030
Replace older drayage trucks	19–48%	48–60%	43–62%	34–52%
Replace older switcher locomotives	16–34%	17–43%	22–44%	24–47%
Replace older CHE	17–39%	13–25%	18–37%	12–25%
Replace or repower CHC	10–24%	25–38%	13–41%	28–37%
Reduce OGV hoteling emissions with shore power	4–9%	7–16%	3–8%	7–16%

The executive summary of EPA's National Port Strategy Assessment: Reducing Air Pollution and Greenhouse Gases at U.S. Ports report is available here: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100PGT0.pdf [18]

- **Infrastructure upgrade:** Upgrades may involve electrification or automation to reduce dependence on diesel-powered equipment and improve efficiency; examples of upgrades include installing fully electric or hybrid cranes, expanding the pier to increase port efficiency, streamlining truck routes to avoid idling and expanding the capacity of port railyards to cut down on reliance on trucks.
- **Best management practices (BMP):** Operational enhancements or BMP are changes made to the management and operation of ports to reduce emissions, including reducing vessel speed within the port vicinity, optimizing shipping routes, reducing vessel idling time, and implementing best practices for cargo handling and storage. Port authorities can encourage or offer incentives to tenants for adopting cleaner practices or to use cleaner equipment.

Many of the strategies implemented at the federal, state, local, or port-level are a combination of either two or more of the categories listed above. For example, a grant to incentivize and hasten the adoption of zero-emission drayage trucks has elements of the incentive program, alternative fuel, and equipment upgrade.

2.2 Federal-Level Strategies

In this section, the TTI study team lists several examples of federal regulations and incentive measures that aim to reduce port emissions.

2.2.1 Federal Regulatory-Based Strategies

Several US federal regulations that aim to regulate and reduce port emissions include:

- **Maritime Pollution (MARPOL) Annex VI** [19] – MARPOL Annex VI is an international treaty that sets air pollution standards for ships by the IMO. This treaty mandates the reduction of air emissions from ships, including SO_x, NO_x, and PM. Annex VI applies to all ships engaged in international voyages, and its provisions establish ECAs[2] where stricter controls are in place. It also sets global standards for sulfur content and NO_x emissions from new ship engines and has adopted an initial strategy to reduce ship-source GHGs by at least 50% by 2050 compared to 2008 levels. The IMO has scheduled stringent emission controls for maritime vessels in 2020 to further reduce emissions. The US is a signatory to the convention and has incorporated its provisions into federal law.
- **Clean Air Act (CAA)** [20, 21] – Under the CAA, the EPA has established several emission standards for several marine vessels.
    - The EPA has also created regulations, such as the *MARPOL Annex VI* and the *Control of Emissions from New and In-Use Marine Compression-Ignition Engines and Vessels*, to lessen emissions of NO_x, PM, SO_x, and other pollutants from port-related sources. Additionally, ports are subject to the CAA's *General Compliance Provisions*, which impose emissions testing, maintenance, and reporting requirements.
    - One of EPA's major initiatives involves the regulation of diesel fuel sulfur content, with the current requirement being that the sulfur content should be decreased to 15 ppm, referred to as ultra-low sulfur diesel (ULSD).
    - The EPA has implemented Tier 4 standards for newly built marine vessels. These standards require the application of high-efficiency after-emission after-treatment technology, which has been mandated since 2014. This technology aims to reduce emissions from diesel engines.

[2] ECAs that are currently in effect include the Baltic Sea, North Sea and English Channel, the US Caribbean ECA (which covers specific waters next to Puerto Rico and the US Virgin Islands), and the North American ECA (which covers areas adjacent to the Pacific Coast, the Atlantic/Gulf Coast and the eight main Hawaiian Islands, up to 200 nautical miles from the coasts of the United States, Canada, and the French territories). See: http://www.imo.org/en/MediaCentre/HotTopics/GHG/Documents/FAQ_2020_English.pdf

- In addition, the sulfur content of bunker fuels used in marine vessels has been regulated by the EPA. There is a global cap of 3.50 weight percent of sulfur content outside of ECA boundaries. The limit on sulfur content is even more stringent within ECAs, where it is capped at 0.1 (1,000ppm) weight percent. These regulations are aimed at reducing the harmful emissions from marine vessels, both locally and globally.

- **Control of Emissions from New and In-Use Marine Compression-Ignition Engines and Vessels** [22] – This regulation establishes emission standards for newly-built and in-use marine compression-ignition engines and vessels, to reduce SO_2, NO_x, and other harmful pollutants from marine engines and vessels. Compliance is required for many types of vessels, including those operating in and around ports.

- **Engine-Testing Procedures** [22] – This regulation establishes procedures for testing and certifying engines used in nonroad and stationary sources of emissions, including marine vessels used in ports. The testing and certification of new and in-use engines are required to comply with the specified requirements, and the compliance and enforcement provisions are also outlined. Measuring emissions during various modes of engine operation, such as idle, transient, and steady-state modes are included in the testing procedures for marine engines. The emission control information label, which includes important information such as the engine's family and model, the emission standards it meets, and the date of manufacture, must be provided on the engine or vessel by engine manufacturers according to the regulation.

- **General Compliance Provisions for Highway, Stationary, and Nonroad Programs** [22] – The program aims to reduce emissions from vehicles and equipment. A wide range of programs is covered by the provisions, including those related to ports, which must comply with regulations for nonroad engines and equipment. The provisions encompass requirements for emissions testing, maintenance, and reporting, as well as penalties for noncompliance. Guidance and assistance are provided by the EPA to help port authorities, state and local agencies, and private entities meet General Compliance Provisions requirements.

2.2.2 Federal Voluntary-Based Measures

Examples of voluntary measures at the federal level include:

- **EPA's SmartWay** – The EPA developed the SmartWay voluntary program to address the significant expansion and projected growth in US freight activities in the upcoming decades. The voluntary program offers a comprehensive system for documenting and sharing information on fuel usage and freight emissions across the supply chain through the SmartWay Transport Partnership. More information is available at: https://www.epa.gov/smartway/learn-about-smartway.

2.2.3 Federal Incentive-Based Strategies

Examples of federal funding/grants to incentivize port emissions reduction include:

- **Diesel Emissions Reduction Act (DERA)** [23] – The DERA funds, established by the 2005 Energy Policy Act, is a funding/grant that promotes diesel emission reduction. National competitive grants and rebates that support projects using EPA or California Air Resources Board (CARB)-certified diesel emission reduction technology were designated 70% of the funds, while 30% were allocated to states and territories to finance diesel emissions reduction projects. The EPA has authorized up to $200 million annually through 2011 when the DERA funds were first appropriated. In 2020, DERA was reauthorized for up to $100 million annually through 2024.
- **Inflation Reduction Act** [24] - A new program with a budget of $3 billion to provide grants and rebates to promote the purchase and installation of zero-emission equipment and technology at ports; in addition, $750 million of the total funding will be spent in nonattainment areas. Additionally, the program provides funding for the development of climate action plans that outline emission reduction goals, implementation strategies, and inventory practices for ports. Eligible recipients for the funding include port authorities, state, regional, local, or Tribal agencies with jurisdiction over ports, air pollution control agencies, and private entities that own or operate port facilities, CHE, transportation equipment, or related technology.
- **Port Infrastructure Development Program (PIDP)** [25]- MARAD administers the PIDP, which is a discretionary grant program. Projects that enhance the safety, efficiency, or reliability of the movement of goods within a port or to/from a port

are eligible to compete for funds under the PIDP. In fiscal year (FY) 2023, the Bipartisan Infrastructure Law (BIL) allocated $450 million to the PIDP. The FY 2023 Consolidated Appropriations Act also provided an additional $212,203,512 to the program, resulting in a total of $662,203,512 in grant funding available.

2.3 State, Local, and Port-Level Strategies

While the US EPA has legal authorities to address some of port-based emissions, they do not have the authority to deal with all of them. For example, the US EPA has no authority to mandate the use of clean equipment at ports, nor could they implement any sort of control on the operating hours of port equipment. Local port authorities play a crucial role in reducing port emissions and mitigating the adverse impacts of shipping on air quality and public health [26]. Thus, it becomes increasingly important for state or local agencies, such as the TCEQ, to implement effective strategies based on their expected benefits, cost-effectiveness, and the cost and time required to implement.

The TTI study team reviewed hundreds of state, local, and port-level emission reduction strategies conducted by state agencies and port authorities across the US.

2.3.1 Prioritized Lists of Sea Ports for Literature Review

To ensure the most detailed literature review work, the TTI study team developed a list of sea ports to prioritize based on their size and location. In this section, an overview of how this list was developed is discussed.

2.3.1.1 Data Sources

- Non-attainment counties: Downloaded in Excel Spreadsheet format from: https://www3.epa.gov/airquality/greenbook/downld/nayro.xls [27].
- US county-level shapefile: Downloaded from the US Census Bureau website: https://www2.census.gov/geo/tiger/GENZ2018/shp/cb_2018_us_county_500k.zip), and then joined to the non-attainment county list by their FIPS number using ArcGIS Pro.
- Principal Ports: Principal ports refer to the top 150 US ports based on total annual tonnage for the year 2020. Shapefile downloaded from the Bureau of Transportation Statistics (BTS) website: https://geodata.bts.gov/datasets/usdot::principal-ports/about.

Using ArcGIS Pro, the TTI study team was able to combine the BTS principal ports data with the EPA's non-attainment county list. More details on the location and tonnage of each principal port are available in Appendix A.

2.3.1.2 List of Prioritized Ports for this Study

The TTI study team retained the top 15 port authorities in the country based on tonnage. The TTI study team eliminated all ports that constituted less than 1% of the total tonnage (2,530,330,203 tons). Among the remaining ports, TTI selected the ones located in NAAQS nonattainment areas. The priority list, comprising 18 port authorities, is displayed in Table 3.

Table 3. List of Prioritized Ports for this Study based on Total Tonnage and Nonattainment Status.

Port Name	Nonattainment	Rank	Total Tonnage[1]	Percentage[2]
POH, TX	Yes	1	275,940,289	11%
Port of South Louisiana (POSL), LA,	No	2	225,086,697	9%
Corpus Christi, TX	No	3	150,755,485	6%
Port Authority of New York and New Jersey (PANYNJ), NY and NJ	Yes	4	123,697,438	5%
Port of New Orleans, LA	No	5	81,067,448	3%
POLB, CA	Yes	6	79,178,087	3%
Port of Greater Baton Rouge, LA	Yes	7	71,686,872	3%
Port of Beaumont, TX	No	8	70,567,386	3%
POLA, CA	Yes	9	59,452,139	2%
Port of Virginia, VA,	No	10	58,048,785	2%
Port of Mobile, AL	No	11	53,206,561	2%
Plaquemines Port District, LA	No	12	46,750,799	2%
Port of Savannah, GA	No	13	43,453,044	2%
Lake Charles Harbor District, LA	No	14	43,053,658	2%
Port Arthur, TX	No	15	41,222,200	2%
Port Freeport, TX	Yes	16	38,748,662	2%
Port of Baltimore, MD	Yes	18	35,202,027	2%
Texas City, TX	Yes	20	33,721,312	2%

[1] The total tonnage comprises both domestic and foreign tonnages, while the foreign tonnage encompasses both imports and exports. Appendix A provides a detailed breakdown of these numbers.

[2] Percentage of the total tonnage of all 150 principal ports in 2020, which was 2,530,330,203 tons.

While Cincinnati-Northern Kentucky and Mid-Ohio Valley satisfy the tonnage requirements and are located within a non-attainment county, they were not included because they are a statistical area and are not port authorities. Lastly, although the St. Louis Metro Port met both requirements, it is an inland port. Therefore, TTI omitted it from the priority list as the focus of the study is directed toward seaports. A list of contacts for the ports on the Table 3 Priority list is available in Appendix B.

Many of the port authorities on the priority list were also awarded DERA funds for diesel emission reduction projects, as shown in Table 4 [28]. A list of these projects is available in Appendix C.

Table 4. Total DERA Funds Awarded to Ports and the Number of Projects Supported through DERA Funds.

Port Name	Equipment Upgrade/Replacement	Shore Power	Incentives	Alternative Fuel	Total Project Funded	Total DERA Funds Awarded
PANYNJ	21	1	1	0	23	$35,222,090
POLB	15	0	0	0	15	$20,974,836
POH	7	0	1	1	9	$17,338,294
POLA	10	1	0	0	11	$12,251,074
Port of Baltimore	9	0	0	0	9	$11,758,801
Port of Virginia	8	0	1	0	9	$8,830,047
Port of Savannah	8	0	0	0	8	$8,330,625
Port of New Orleans	5	0	0	0	5	$5,365,746
Port of Mobile	3	0	0	0	3	$2,732,439
Port of Corpus Christi	2	0	0	0	2	$1,966,910
Port of Greater Baton Rouge	1	0	0	0	1	$1,556,733

2.3.2 Strategy Review Visualization Dashboard

To facilitate the analysis using a large amount of information gathered, a Tableau Dashboard, as shown in Figure 3, was prepared so users can quickly and easily navigate the information that has been gathered and provides a simple and intuitive interface for exploring the findings of the study[3]. The user can filter the dashboard for the source

[3] The dashboard is available at: https://tableau.tamu.edu/#/site/TTI/views/PortLiteraturereviewvisualization_2_1Apr2023/PortStrategyDashboard?:iid=2.

category, pollutants, and strategy type. In addition, the user can also toggle the dashboard to only show strategies that list pollutants targetted and emissions reduction targets. Users can also click on the "Download" button to generate a PDF of the current selection for ease of documentation.

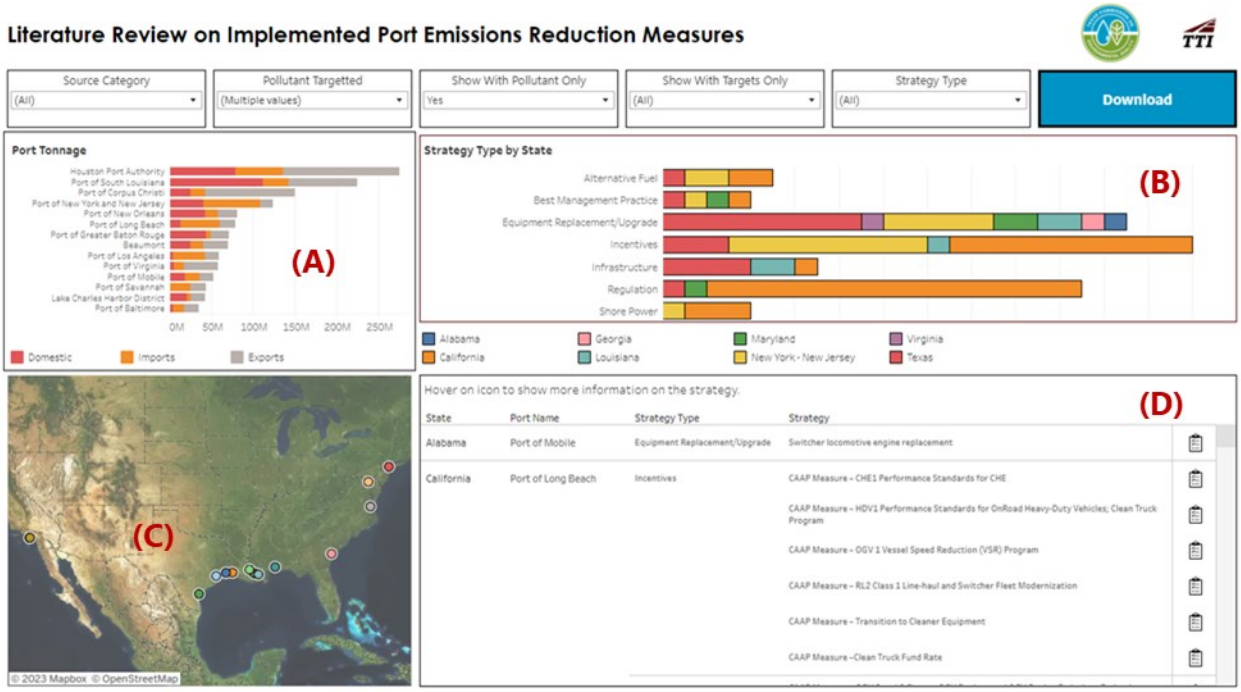


Figure 3. Snapshot of the Dashboard Layout to Visualize the Port Emission Reduction Literature Review Study Results.

The Dashboard can be separated into four sections:

- **Section A** shows the total tonnage at each port. The domestic, import, and export tonnages are differentiated by color. Adding them together yields the port's total tonnage.
- **Section B** shows stacked bar charts that indicate the quantity of emission reduction strategies that have been implemented at each port according to strategy type (i.e., regulation, incentives, equipment upgrade, shore power), and they are color-coded by state. When the user clicks on a specific bar in the chart, the dashboard will filter the information to only show data relevant to the selected state.
- **Section C** shows a map that displays circles to represent each port. If the user clicks on a circle, the dashboard will filter the information to display only data

related to the selected port. Hovering over a circle will reveal a tooltip, as depicted in Figure 4. This tooltip displays a tally of emission reduction strategies according to their strategy type (i.e., regulation, incentives, equipment upgrade, shore power) that have been associated with the port.

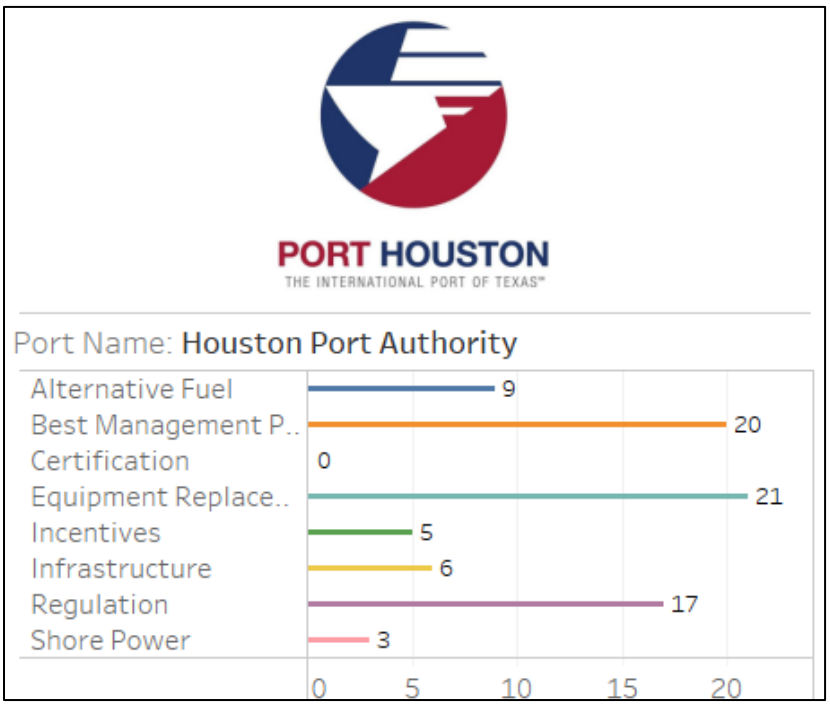


Figure 4. Snapshot of the Tooltip showcasing the number of Emission Reduction Strategies by Type.

- **Section D** displays a table that lists all the information collected from the literature review. The table is organized in the following order: state, port, strategy category, and strategy name. By hovering over the blue circle icon on the Dashboard table, users can see a tooltip that displays all the relevant information for that row, an example is shown in Figure 5. This tooltip includes details such as the name of the strategy, the source of the information, and a summary of the findings. Additionally, the tooltip also includes a link labeled "Go to Strategy Webpage." This link allows users to access the webpage where the TTI study team found the information that is being displayed in the tooltip. This feature enables users to access the source material easily and quickly for each strategy, which can be helpful for further research or investigation.

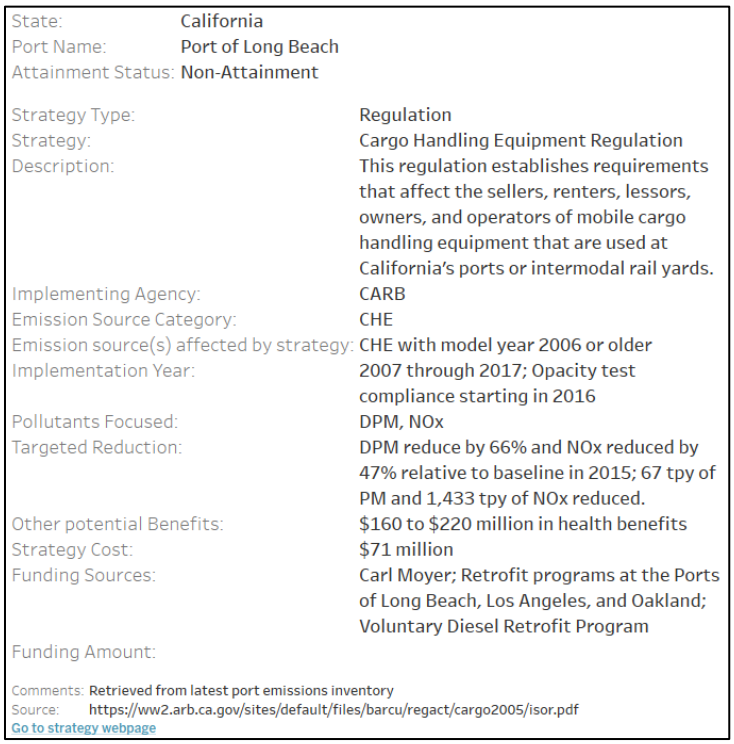


Figure 5. Snapshot of the Tooltip showing Information Collected from the Literature Review.

2.3.3 Major Findings in the State, Local, and Port-Level Strategies

As shown in Figure 6, in total, the TTI study team reviewed and documented 340 strategies implemented at 15 of the largest port authorities in the nation, which covers 9 states (PANYNJ is operated by a bi-state agency).

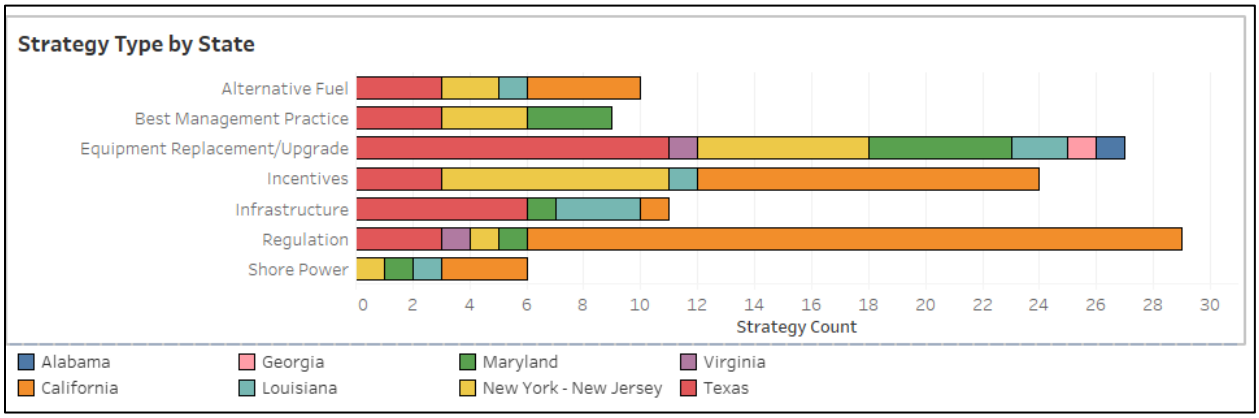


Figure 6. Breakdown of all Port Emission Reduction Strategies by Strategy Type and State.

Many strategies were implemented by parties aside from the port authorities, including state and local government, metropolitan planning organizations (MPO), local advocacy groups, and other stakeholders. Equipment replacement or upgrade is the most popular strategy among the reviewed ports, which includes the upgrade of older, more polluting engines to newer, cleaner ones (i.e., converting Tier 0 or 1 engines to Tier 3 or 4 in tugboats) or replacing on-road fleets or CHE with low-emission or zero-emission options (i.e., electrifying forklifts operating in the ports). Shore power is the least popular option among the strategy category, and the Texas ports reviewed for this study (which include some of the largest ports in the nation, i.e., POH and Corpus Christi) have yet to implement strategies to connect CHC and OGVs to shore power. Although the implementation of shore power is not widespread in Texas, a few ports in the state, such as the Port of Beaumont and the Port of Galveston, have already begun utilizing shore power in a limited capacity [16]. In addition, several Texas ports have conducted studies to explore the advantages and feasibility of adopting shore power. For example, the Port of Galveston is currently assessing the feasibility of implementing shore power for one of its primary cruise ship clients, and it may also explore the possibility of adopting shore power for other cruise, container, and refrigerated ship activities [16].

The TCEQ project manager had conveyed to the TTI study team that TCEQ plans to focus on CHC and OGV related studies. It was also noted that TCEQ's research mostly focused on NO_x and volatile organic compounds (VOC), which would prioritize strategies with emission reduction qualities for these pollutants. TTI filtered the dashboard to show only strategies concerning CHC, OGV, and/or port infrastructure with a focus on NO_x and VOC emission reduction, as shown in Figure 7.

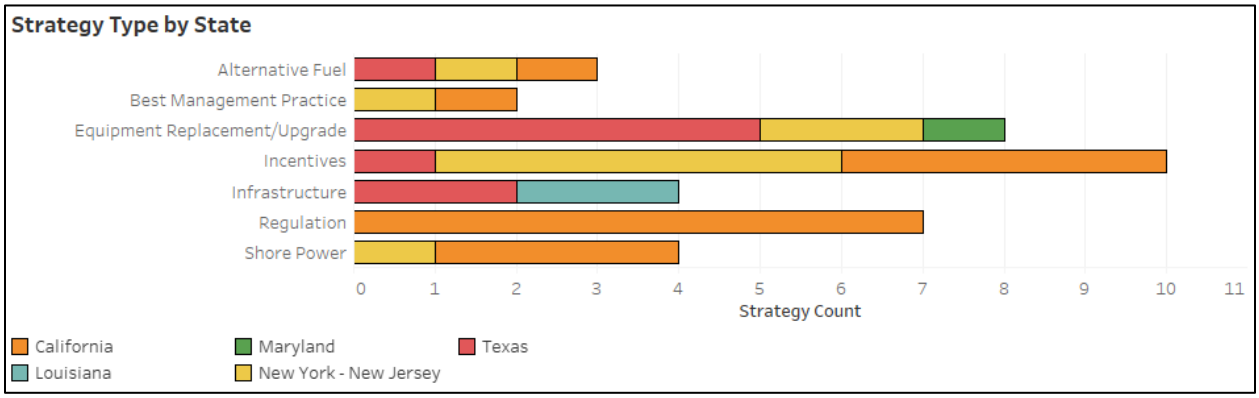


Figure 7. The number of CHC, OGV, and/or Port Infrastructure Emission Reduction Strategies with NO_x and/or VOC benefits.

Based on literature review and analysis, and with the approval of the TCEQ project manager, the TTI study team chose the following strategies for further review:

- **Incentives-related strategies:**
    - **Environmental Ship Index (ESI) programs**: Implemented by PANYNJ, POLA, and POLB. The ESI Program is an international clean ship indexing program developed through the International Association of Ports and Harbors' World Ports Climate Initiative. Operators registered under this program earn an ESI score for their vessels by using cleaner technology and practices that reduce emissions beyond the regulatory requirements set by the IMO. This program rewards vessel operators for reducing emissions in advance of regulatory requirements. It rewards vessel operators for bringing their newest and cleanest vessels to ports and demonstrating clean technologies.
    - **Vessel Speed Reduction (VSR)**: Implemented at PANYNJ[4], POLA, and POLB. This strategy's concept is based on lowering the speed where OGVs are operating while within port vicinity thus decreasing engine emissions. The port authority will provide financial incentives for OGV operators.
- **Equipment/vehicle repower, retrofit, or replacement:**
    - **Harbor Deepening NO_x Offset**: Implemented by the PANYNJ. Thirty-six ferries and tugboats were repowered, retrofitted, or replaced to offset more than 7,000 tons of NO_x that were emitted by the New York/New Jersey harbor deepening project [29].
    - **Globalplex Intermodal Improvements**: Implemented at the Port of Southern Louisiana (POSL). This strategy included installing two electric mobile harbor cranes that would increase loading-unloading efficiencies. By replacing diesel-powered cranes, POSL not only reduces emissions but also minimizes vessel idling time, resulting in a significant overall decrease in total emissions [30].
    - **2022 CHC regulation amendments**: Implemented by CARB. This amendment requires zero-emission options where feasible, and cleaner combustion Tier 3 and 4 engines on all other vessels. Short-run ferries,

[4] PANYNJ combined the ESI and VSR into a singular Clean Vessel Incentives (CVI) program.

which include those traveling less than three nautical miles over a single run, will be required to be fully zero-emission by the end of 2025. New excursion vessels, such as vessels offering whale watching or dinner cruises, are also required to be capable of operating with at least 30% of the power from a zero-emission source.

  - **CHE fleet modernization program** – Implemented at PANYNJ. This program reimburses 20% of the cost of replacing older CHE with new equipment that meets EPA's on-road or off-road vehicle standards, whichever is applicable. This $2.24 million strategy is expected to replace 125 pieces of CHE.
  - **Performance standard for CHE** – Implemented by CARB. This regulation was implemented between 2007 and 2014. Under this regulation, CHE purchases are required to meet the cleanest technology for NO_x available or installed with the cleanest Verified Diesel Emission Control Strategy (VDECS). CHE affected would all need to meet EPA's Tier-4 engine standards by 2014 or be equipped with the cleanest VDECS until they can be replaced.

- **Shore Power:**
  - **Brooklyn Cruise Terminal Shore Power**: Implemented at PANYNJ. $2.85 million in DERA grants were granted to partly cover the cost of installing shore power at PANYNJ's Brooklyn Cruise Terminal. The $21 million project aims to reduce 95 tons of NO_x over its lifespan [31].
  - **OGV at Berth**: Implemented by CARB. This regulation requires container, passenger, and refrigerated-cargo ships to reduce at-berth emissions by plugging into shore power or by using other emission control methods. This regulation was updated in 2020 to meet the 2023 and 2031 NO_x reduction goals [32].

2.4 Chapter Summary

The strategies that the TTI study team decided to pursue further research, with authorization from the TCEQ project manager, are mainly implemented by 5 organizations: one state agency (CARB) and four-port authorities (POLA, POLB, POSL, PANYNJ). Due to the relatively low number of target agencies as well as the complexity

of topics (which may not overlap between entities), the TTI study team believed that it would be more beneficial to interview the port authority representative, rather than sending survey questionnaires to them.

More information regarding the targetted in-depth research conducted on the strategies listed in Chapter 2.3.3 can be found in the subsequent chapter. In cases where relevant and key information was not initially obtained by the TTI study team, efforts were made to reach out and interview the respective agency representatives. These interviews provided the TTI team with an opportunity to gain a deeper understanding of the strategies beyond what was initially reported. It allowed for exploring additional aspects such as the reception of the strategies, planned updates, and any forthcoming strategies that the agency intends to introduce in the future.

3 DATA COLLECTION AND SURVEY OF PORT AUTHORITIES AND OPERATORS

This chapter documents the work the TTI study team performed as part of **Task 4 - Data Collection and Survey of Port Authorities and Operators**. While executing Task 4, the TTI study team identified that the deliverables for Tasks 4 and 5 (*Estimate the Emissions Impact and Cost-effectiveness of the Selected Strategies*) should be executed concurrently. Upon discussion, the TCEQ project manager agreed with the TTI assessment and approved the adjustment of Task 4 delivery dates to align with those of Task 5.

The TTI study team developed and provided a data collection and survey plan of the information to be collected from the port authorities/agencies and their operators/vendors. TTI documented the status of data collection efforts, the design of interview questions, the status of interview efforts, and a communication log between the TTI study team and port authority staff.

3.1 STATUS OF THE SECOND ROUND OF LITERATURE REVIEW

In this section, the status of the second round of reviews based on the Task 3 findings (as discussed previously in Chapter 2.3.3) is discussed. Further details regarding the review and analysis of these strategies are provided in the next chapter.

As seen in Table 5, the TTI study team was able to acquire relevant data and information necessary for Task 5 for most strategies from reports and articles published by the agencies. For most strategies, the TTI study team was also able to produce emission reduction calculations using methodologies/formulas either in the EPA's *Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emission Inventories* [33] report or the *San Pedro Bay Ports Emissions Inventory Methodology Report Version 3a* [34]. For shore power calculations, the TTI study team used the 2023 version of the EPA's Shore Power Emissions Calculator (SPEC)[5] to produce emission reduction estimates. These calculations used reported aggregated values from the source or state or nationwide average values from the state agencies or EPA. As the TTI study team was using aggregated and/or averaged values, the calculated emissions reduction did not

[5] The EPA's SPEC is available at: https://www.epa.gov/ports-initiative/shore-power-technology-assessment-us-ports

perfectly match the reported values, so the TTI study team performed a reasonableness check on the calculations to ensure the calculation and methodologies were sound.

Table 5. Status of Strategy Based on Literature Review and Data Gathering Results.

Strategy	Port	Emission Reduction	Cost of Implementation	Timeline
ESI programs	PANYNJ, POLA, POLB	NA	NA	NA
VSR program	PANYNJ, POLA, POLB	Available; Calculated [35]	NA	NA
Harbor Deepening Project NOx Offset	PANYNJ	Available; Calculated [33]	NA	Available
Globalplex Intermodal Improvements on Harbor Cranes	POSL	Available; Calculated [33]	Available	Available
CARB – OGV at Berth (Shore Power)	All Californian ports	Available; Calculated [36]	Available	Available
CARB – OGV at Berth (Emission Capture System)	All Californian ports	Available	Available	Available
CARB – OGV Fuel Regulations	All Californian ports	Suggest dropping this strategy as it focuses on reducing SO_2 and CO_2, but has minimal impact on VOCs and NO_x emissions.		
CARB - 2022 CHC regulation amendments	All Californian ports	Available; Calculated [37]	Available	Available
CARB – CHE Performance Standard	All Californian Ports	Available; Calculated [33]	Available	Available
Brooklyn cruise terminal shore power	PANYNJ	Calculated [38]	Available	Available
PANYNJ CHE fleet modernization program	PANYNJ	Calculated [33]	Available	Available
LSI engine requirements	POLB, POLA	Suggest dropping this strategy as it mainly focuses on reducing emissions from on-road trucks, with only a minor overlap with port emissions through trucks that travel to ports.		

NA – Information not available; Available – Information is reported; Calculated – The TTI study team was able to calculate the estimation based on available information based on documented methodologies by EPA or the state agencies.

The TCEQ project manager informed the TTI study team that the TCEQ is mainly focused on strategies that affect OGVs, CHC, and on-site CHE and is focused on reducing NO_x and VOC, which are precursors to the formation of ground-level ozone. The Houston-Galveston-Brazoria (HGB) district, where POH, Texas' largest port, is located, is currently non-attainment under the ozone NAAQS but is in compliance with the NAAQS for the other criteria air pollutants, including SO_2 and $PM_{2.5}$. Upon closer examination of certain strategies, the TTI study team recommended dropping the OGV Fuel Regulation and Large Spark Ignition (LSI) Engine Requirements strategies from the list, as the former mainly focuses on reducing SO_x, $PM_{2.5}$, and CO_2, while the latter is primarily an on-road

truck strategy with only minor overlap with port emissions through drayage trucks (on-road sources).

Table 5 shows that three strategies, namely the ESI program, the VSR program, and the NO_x offset from the harbor deepening strategy, have "NAs" in some or all columns. The TTI study team was unable to gather any information on the ESI program from any of the three ports, aside from basic descriptions. Other studies have also noted that the lack of publicly available data or information regarding the ESI participation rate at any of the ports makes it difficult to assess the program [39]. Compliance reports for the VSR programs were available for all three ports. Although the vessel class and engine tiers were not available in these compliance reports, the team used the vessel breakdowns from the ports' latest emission inventories (EI) to estimate the composition of the vessels in compliance and produce emissions reduction estimates comparable to reported values. However, the TTI study team was not able to find any information on the annual cost of executing the VSR program (the San Pedro Bay Ports only had estimates from before the program started, while the PANYNJ only had information on the cap of what the port authority is paying annually). There was also no information on whether the VSR programs have a sunset period, i.e. ending timeframe. Lastly, the TTI study team was not able to find information on the cost for PANYNJ's harbor deepening NO_x offset strategy, which involves replacing 36 tugboats and ferries. On May 5th, 2023, the TTI study team sent interview requests and questionnaires to the port authorities at POLA, POLB, and PANYNJ to gather more information needed to bridge the data gaps.

3.2 Interview Questionnaires and Targets

This section lists the interview targets that the TTI study team had identified, the questionnaires that were used, as well as a summary of the interview.

3.2.1 Interview Questionnaires

The TTI study team prepared the questionnaires for POLA, POLB, and PANYNJ for the strategies where information was not available through literature review and data gathering. The questionnaires are shown in Appendix D.

3.2.2 Interview Targets

The TTI study team contacted the PANYNJ, POLA, and POLB staff listed in Table 6 for an interview on May 5th, 2023. Charles Liou from PANYNJ agreed to an interview with the TTI study team, set on May 19th, whereas Heather Tomley from POLB had conveyed to the TTI study team that she will convene internally to formulate a response to the questionnaires. The TTI study team did not hear back from the POLA representative, David Libatique. A log of the conversation between TTI and the port authority contacts is presented in Appendix E.

Table 6. Contacted port authority personnel.

Port	Name	Title	Phone	Email
PANYNJ	Christopher Zeppie	Director Office of Environmental Policy, Programs & Compliance	(212)-435-4415	czeppie@panynj.gov
	Charles Liou	Manager, Environmental Initiatives	(212- 435-4431	cliou@panynj.gov
POLB	Heather Tomley	Managing Director, Planning and Environmental Affairs Bureau	(562)-283-7117	heather.tomley@polb.com
POLA	David Libatique	Deputy Executive Director, Stakeholder Engagement	(310)-732-3905	dlibatique@portla.org

3.2.3 PANYNJ Interview Summary

On May 19th, 2023, the TTI study team conducted a Teams interview with Tanja Grzeskowitz, the Environmental Programs Principal and Specialist at PANYNJ, who substituted for Charles Liou. The questions are included in Appendix D.

Tanja discussed the advantages of merging the ESI and VSR programs into a single program called the Cleans Vessel Index (CVI). She explained that the ESI serves as a useful tool for tracking information on vessels participating in the VSR program, facilitating the development of emissions inventories, and calculating emissions reductions resulting from VSR. Combining the ESI and VSR into one program streamlines the administrative and tracking processes.

Tanja also mentioned that as vessel sizes continue to increase, the number of vessels qualifying for the CVI program decreases. This reduction in the qualifying vessel counts results in lower annual incentive payments. She noted that it's important to proactively configure the incentive benefits of the program to account for changes in the OGV population. Fleet owners often seek ways to maximize incentives without achieving a

proportionate reduction in emissions compliance. Furthermore, Tanja noted that PANYNJ is exploring the possibility of shortening the ESI auditing period for OGVs. This is due to frequent changes in ownership, which can complicate or disrupt the auditing process. Furthermore, due to the frequent transfer of ownership of these OGVs, it is essential to track them using their Maritime Mobile Service Identities number.

PANYNJ plans to pursue several additional emissions reduction strategies in the future:

- Replacing drayage trucks with zero-emission trucks.
- Funding pilot boat turnovers without requiring scrappage.
- Expanding their alternative fuel strategy beyond their current 2022 alternative fuel incentives.
- Modifying their CHE strategies to include requirements for zero-emissions vehicles whenever possible.
- Installing cameras and fiber optics to improve enforcement on truck idling within the ports.

Tanja also mentioned that the EPA underestimates the lifetime of Tier 0 equipment. These older and simpler equipment are easier to repair compared to newer and more complicated equipment, which results in them remaining in the fleet for a longer period than estimated by the EPA. Therefore, the port must proactively provide incentives for the retirement of Tier 0 equipment.

3.3 Chapter Summary

By conducting an interview documented in this chapter, the TTI study team successfully obtained crucial information to fill in the data gaps as listed in Table 5. Specifically, the interview provided details regarding the cost, quantification of emission reductions, and implementation timeline of the ESI, VSR, and PANYNJ NO_x offset strategies.

4 ESTIMATE THE EMISSIONS IMPACT AND COST-EFFECTIVENESS OF THE SELECTED STRATEGIES

This chapter documents the work the TTI study team performed as part of **Task 5 - Estimate the Emissions Impact and Cost-effectiveness of the Selected Strategies**.

In this task, the TTI study team evaluated the selected strategies previously discussed in Chapter 2.3.3. The TTI study team quantified potential emissions benefits (using an approved calculation methodology), estimated an implementation timeline, or range, and performed a cost benefit analysis for each selected strategy. The TTI study team evaluated the strategies based on expected benefits, cost-effectiveness, and the cost and time required to implement them. In addition, TTI performed quality assurance (QA) by comparing the results with those established nationally and in other states.

4.1 Data Sources and Calculations

The cost of each strategy was obtained from reports or the port authority website that documented the specific strategy. These reports typically provide a detailed breakdown of the costs associated with equipment, labor, and maintenance involved in implementing the strategy.

The cost-effectiveness of each pollutant species is presented as a cost-per-ton ($/ton) metric. This metric is calculated either by dividing the total cost of the strategy by the lifetime emissions reduction or by multiplying the annual cost of the strategy by the capital recovery factor (CFR) and dividing it by the annual emissions reduction. CFR is calculated using the following equation:

$$CFR_{i,N} = \frac{i(1+i)^N}{(1+i)^N - 1}$$

Where,

i = real discount rate

N = number of years

The emissions reduction for each strategy are calculated slightly differently based on the strategy and source type (i.e., CHC, CHE, OGV, etc.). In general, the pollutant emitted from the diesel engine can be calculated using the following formula:

$$Emission\ [Ton] = Engine\ Power\ [kW] \times Annual\ Activity\ [Hr] \times Emission\ Factor\ \left[\frac{g}{kW-Hr}\right] \times Load\ Factor \times 0.00000110231\ [\frac{Ton}{g}]$$

The population of the vehicle or equipment, engine power, and annual activity are based on the source type and size bin averages that was reported in the latest EIs. Emission and load factors were retrieved from either EPA [33], CARB [36, 37], or the port authorities' [34, 40, 41] report.

For CHE, the emission factor was calculated using the formula below:

$$Emission\ Factor_{CHE} = ZH + (DR \times Cumulative\ Hours)$$

Where,

ZH = zero-hour emission rate for a given horsepower category and model year when the engine is new and the emissions control systems are functioning normally, g/kW-hr

DR = deterioration rate (rate of change of emissions as a function of equipment age), g/kW-hr^2

Cumulative hours = total number of hours the engine has been in use and calculated as annual operating hours times age of the engine, hours

The *ZH* and *DR* for CHE were retrieved from the San Pedro Bay Ports' *Emissions Inventory Methodology Report* [34].

4.2 Emission Reduction and Cost Benefit Calculation Excel Spreadsheet

The TTI study team compiled the findings from the comprehensive literature review on the subjects listed in Table 5 from the previous chapter and organized them into a set of Benefits Calculation Spreadsheets (henceforth known as Spreadsheet) on Excel, which contains various details such as:

- Strategy name, type, and description
- Implementing port (s) and their NAAQS nonattainment area status
- Affected emission sources (i.e., OGV, CHC, etc.)

- Funding sources
- Implementation timeline (start and end date)
- Cost of strategy
- Emission reduction benefits for various pollutant species (i.e., NO_x, VOC, CO_2, etc.)
- Cost benefit analysis

Figure 8 shows a snapshot of the spreadsheet. Users can navigate to specific strategies on the spreadsheet through the landing page's links, as shown in Figure 9.

Strategy Name	Ocean Going vessel at Berth - Shore Power
Strategy Type	Shore Power
Port Name	Port of Los Angeles, Port of Long Beach, Port of Oakland
NAAQS Attainment/Nonattainment Area	Nonattainment
Strategy Information	The goal of the Ocean-Going Vessels At Berth Regulation is to reduce diesel particulate matter (PM) and oxides of nitrogen (NO At Berth Regulation is projected to reduce emissions from 2,300+ additional vessel visits (in addition to the 4,000+ visits control total reductions from 2021 to 2032. The following strategies are part of the regulation: 1. **Shore power** - Supply of shore power to vessels at berth may require new or increased support infrastructure. Once in full imp annually). **2. Capture and control system** - Once a vessel is at berth and ready to be worked, a tug moves the barge alongside the vessel, a stack to "capture" the emissions. Then a small engine on the barge creates a vacuum to pull the vessel exhaust through the duct 3. **On-board technologies** - (i) selective catalytic reduction, (ii) scrubbers, (iii) water/fuel emulsion, (iv) distributed generation of 4. Alternative fuel 5. **Vessel Incident Event (VIE) or Remediation Fund** - (i) VIE aim to address instances when a vessel is unable to connect to an e emissions. The allowed VIEs are based on a percentage of visits by a California fleet during the previous year, and the number o allows vessels to comply with the Proposed Regulation by remediating lost emissions reductions due to qualified events such a
Affected Sources	OGV, seaports and port terminals
Funding Sources	1. **Low Carbon Transportation – Advanced Technology Demonstration and Pilot Projects** - Capture and Control System for Tan 2. **Carl Moyer Program** - Shore Power and Capture and Control Systems 3. **VW Mitigation Trust** - Shore Power 4. **AB 617 Community Air Protection** - Shore Power and Capture and Control Systems 5. **Clean Off-Road Equipment Voucher Incentive Project** - Cable Reel Management Systems 6. **Proposition 1B – Goods Movement Program** - Shore Power

Strategy Specific Inputs

Strategy Start Year	2020
Strategy End Year	2032
Estimated Cost of Strategy	$ 354,713,922.80

Strategy Duration	12
Discount Rate	0.03
Capital Recovery Factor	0.100462085

Emission Reduction	**Timeframe**	**Emission Reduction (US tons)**	**Cost Benefit ($/ton reduced)**
NOx[5]	TPY	1,920	$ 18,562.95
VOC[5]	TPY	95	$ 373,535.64
PM2.5[5]	TPY	31	$ 1,160,758.97
CO2eq[5]	TPY	43,559	$ 818.09

Sources:	1. CARB, "Interim Evaluation Report – Control Measure For Ocean-Going Vessels At Berth," CARB, Sacramento, 2022. 2. CARB, "At Berth Frequently Asked Questions," 10 April 2023. [Online]. Available: https://ww2.arb.ca.gov/sites/default/files/ 3. CARB (2019). STAFF REPORT: INITIAL STATEMENT OF REASONS. https://ww2.arb.ca.gov/sites/default/files/barcu/regact 4. CARB (2019) Draft Cost Estimates. https://ww2.arb.ca.gov/sites/default/files/2020-04/costestimates%20ADA%20version.xlsx 5. CARB (2019) At Berth Emissions Estimate. https://ww2.arb.ca.gov/resources/documents/berth-emission-estimates 6. CARB (2019). Appendix H 2019 Update to Inventory for Ocean-Going Vessels At Berth: Methodology and Results. https://ww
Additional Notes	a. Emission per vessel Engine = Activity X EP X EF [6]. **Spreadsheet showing emission reduction calculation is available in the** b. Emission reduction retrived from [5]. Based on Auxiliary Engine Emissions reduction for year 2031 for 5 different vessel class. c. Total cost of strategy and breakdown of cost are avaialble below. Both were lifted from the OGV at berth regulation's cost anal **Berth retrofits - 5 containers/reefers, 1 cruise** **Vessel retrofits - 57 container/reefer, 26 cruise**

Figure 8. Snapshot of the Benefits Calculation Spreadsheet.

Strategy	Short Description	Link to Strategy
Shore Power - OGV at Berth	Covers the shore power component of CARB's OGV at Berth startegy	Click here to go to the strategy
Emission Capture System - OGV at Berth	Covers the emission capture system component of CARB's OGV at Berth startegy	Click here to go to the strategy
CARB Commercial Harbor Craft Ammendment (2022)	Replacing older diesel-powered cargo handling equipment (CHE) with newer-cleaner Tier 4 equipments.	Click here to go to the strategy
Cargo Handling Equipment Performance Standard	This regulation established requirements that affect the sellers, renters, lessors, owners, and operators of mobile cargo handling equipment that are used at California's ports or intermodal rail yards	Click here to go to the strategy
CAAP Terminal Equipment Replacement	Replacing older diesel-powered cargo handling equipment (CHE) with electric-powered ones.	Click here to go to the strategy
Brooklyn Cruise Terminal Shore Power	Shore power for cruise ship terminal.	Click here to go to the strategy
Globalplex Intermodal Improvement - Crane Replacement	Upgrading 2 electric cranes to reduce emissions from crane and OGV through decreased dwell time.	Click here to go to the strategy
Cargo Handling Equipment Fleet Modernization	Provide incentives to help replace/upgrade 125 pieces of CHE with Tier 4.	Click here to go to the strategy
Vessel Speed Reduction - Los Angeles	Provide incentives to slow vessel speed to 12 knots within 20nm/40nm.	Click here to go to the strategy
Vessel Speed Reduction - Long Beach	Provide incentives to slow vessel speed to 12 knots within 20nm/40nm.	Click here to go to the strategy
Clean Vessel Index - New York New Jersey	Combine elements of vessel speed reduction (VSR) and Environmental Ship Index (ESI). Provide inventives for vessels owners to upgrade to newer-cleaner vessels or use on-board capture technology, based on the international ESI point system. Provide incentives to slow vessel speed to 10 knots within 20nm.	Click here to go to the strategy
Harbor Deepening NOx Offset	Replacing/upgrading 36 older tugboats and ferries to offset NOx emissions from dredging operation.	Click here to go to the strategy

Figure 9. Landing Page of the Benefits Calculation Spreadsheet.

As some strategies (i.e., VSR, CHE performance standard, etc.) require multiple datasets to complete the calculation, the TTI study team included the calculations and the datasets required in separate attachments, which was delivered to the TCEQ project manager along with the spreadsheet as part of the Task 5 deliverables.

4.3 Major Findings

According to the 2022 *Texas Emissions Reduction Plan Biennial Report*, the cost benefits of Diesel Emission Reduction Incentive (DERI) programs range from an average of $5,796 to $9,131 to reduce one ton of NO_x emissions from vehicles and equipment. The Texas Clean Fleet Program (TCEP) cost an average of $98,594 per ton of NO_x reduced. The Texas Natural Gas Vehicle Grant Program achieved NO_x emission reductions at an average cost of $32,372 per ton. Lastly, the Seaport and Rail Yard (SPRY) Areas Emissions Reduction Program is projected to reduce NO_x emissions at an average cost of $22,022 per ton [42].

Table 7 lists the potential emission reduction and cost benefit for strategies.

Table 7. Implementation Timeline, Emission Reduction [ER], and Cost Benefit [CB] ($/Ton) of the Strategy.

Source	Emission Reduction Strategy (Category)	Implementation Timeline	Variable	NOx	VOC	PM2.5	CO2-equivalent
OGV	PANYNJ - VSR + ESI program (Regulation)	No planned sunset[1]	ER (TPY)	603	26	9	34,675
			CB ($/Ton)	$2,560	$58,418	$170,083	$44
	POLA – VSR (Regulation)	No planned sunset	ER (TPY)	1,185	53	17	65,130
			CB ($/Ton)	$2,485	$55,965	$169,679	$45
	POLB – VSR (Regulation)	No planned sunset	ER (TPY)	962	43	15	55,426
			CB ($/Ton)	$3,064	$68,432	$201,819	$53
	Brooklyn cruise terminal shore power (Shore Power)[2]	15 years[3]	ER (TPY)	32		4	1,383
			CB ($/Ton)	$50,887		$365,437	$1,168
	OGV at Berth (Shore Power)	12 years	ER (TPY)	1,920	95	31	43,559
			CB ($/Ton)	$18,562	$373,535	$1,160,758	$818.09
	OGV at Berth (Emission Capture System)	12 years	ER (TPY)	240	13	18	
			CB ($/Ton)	$270,738	$4,916,362	$3,585,413	
CHC	Harbor Deepening Project NOx Offset (Upgrades/Replacement)	12 years	ER	6,934	179	183	
			CB ($/Ton)	$2,097	$81,354	$79,550	
	2022 CHC regulation amendments (Upgrades/Replacement)	15 years	ER (Lifetime Tons)	34,340	2,460	1,610	457,525
			CB ($/Ton)	$49,562	$691,858	$1,057,125	$3,719
CHE	Globalplex Intermodal Improvements on Harbor Cranes (Electrification)	30 years[4]	ER (Lifetime Tons)	765		56	29,456
			CB ($/Ton)	$15,697		$213,479	$407
	CHE Performance Standard (Upgrades/Replacement)	13 years	ER (TPY)	3,873	106	175	
			CB ($/Ton)	$1,511	$55,424	$33,449	
	CAAP – CHE Replacement (Electirfication)	10 years	ER (TPY)	3,004	232	131	700.,862
			CB ($/Ton)	$133,052	$1,723,557	$3,053,531	$570
	PANYNJ CHE fleet modernization program (Upgrades/Replacement)	14 years	ER (TPY)	111	4	3	
			CB ($/Ton)	$2,001	$54,028	$63,400	

[1]In an interview with PANYNJ staff (see Chapter 3.2.3), it was mentioned that there is currently no specific subset period planned for the popular strategy. As of May 2023, funding for the next five fiscal years had been approved.

[2]Emission reduction calculated using the EPA's Shore Power Emission Calculator (available at https://www.epa.gov/system/files/documents/2022-12/420r22037.pdf). The information of the four cruise ships (Queens Mart 2, Enchanted Princess, Caribbean Princess, and Sky Princess) that reportedly connected to shore power in the year 2022 was used in the calculator. [43]

[3]This strategy does not have a sunset period, however, the average lifespan of a shore power station is 15 years.

[4]The lifespan of gantry cranes was estimated at 30 years.

In comparison, the VSR, harbor deepening NO_x offset, CHE performance standard, and CHE modernization strategies were more cost-effective than the average projects listed

in the 2022 *Texas Emissions Reduction Plan Biennial Report*. In addition, the OGV at Berth shore power and harbor crane electrification strategies demonstrated greater cost-effectiveness compared to the average cost of projects in the SPRY area programs. The emission capture system, cruise terminal, and CHC regulation amendments have cost more to reduce a ton of NO_x compared to the other strategies researched as well as the strategies in the Biennial Report.

4.4 Chapter Summary

Based on the analysis, the TTI study team recommends exploring the following strategies:

- **OGV speed reduction** – The VSR program emerges as one of the most cost-effective approaches for reducing emissions from OGVs, and it offers the advantage of not necessarily requiring equipment upgrades. This aspect contributes to its overall appeal and adoption by PANYNJ, POLA, and POLB. Depending on the compliance rate within the restricted segment (i.e., maintaining speeds of 12 knots within 20 nautical miles), incentives can be provided in the form of rebates or credits. As discussed in Chapter 3.2.3, based on conversations with PANYNJ staff, OGVs participating in the VSR program should also register with the ESI. This enables the port to obtain the most accurate information regarding the participating OGVs. While the registration fees for ESI may pose a hindrance to this strategy, the port can mitigate this by providing additional incentives to OGV owners who bring their cleanest OGVs to the port.
- **Shore power for OGVs at berth** – By transitioning to shore power during berth operations, auxiliary engines on OGVs can be switched off, effectively eliminating emissions from these engines. The costs associated with adopting shore power include the construction of shore power stations, retrofitting or upgrading OGVs to be compatible with shore power, and the expense of electricity to power the OGVs. Implementing shore power can incur substantial costs, necessitating a phased approach over several years and the availability of grants for completion. However, as shown in Table 7, this strategy proves to be significantly more cost-effective compared to most other options and many strategies outlined in the *2022 Texas Emissions Reduction Plan Biennial Report* [42]. Ports can maximize the cost-effectiveness by strategically planning vessel visits to minimize the number of shore power stations required while achieving comparable reductions in

emissions. Lastly, instead of providing incentives for all vessels to convert, ports can prioritize the adoption of shore power in older vessels (Tiers 0 - II). Because newer vessels (Tiers III and IV) are already cleaner and emit fewer pollutants, by focusing on older vessels, ports can effectively target their efforts where the emissions reduction impact will be the greatest. In the *Commercial Marine Vessel Research - Shore Power and/or Alternative Emissions Controls* report that was prepared for TCEQ, similar conclusions were drawn. The report highlighted that container, reefer, and cruise ships have the greatest potential for cost-effective emission reductions. In addition, the report noted that shore power for frequently calling vessels is the most suitable and cost-effective [16].

- **CHC and CHE upgrade, repower, or replacement** – Selective upgrade of older CHC and CHE can yield significant cost-effectiveness. It is crucial to prioritize the upgrade, repower, or replacement of the oldest CHC and CHE in the fleet (Tiers 0 - II), as substituting them with Tiers III or IV CHC and CHE within the same class can lead to a substantial reduction in emitted pollutants. The port can focus on replacing the CHC and CHE owned by the port itself and offer incentives to tenants to replace their non-port-owned CHC and CHE. These incentives could be integrated into leasing renewal agreements. Additionally, as shown by the PANYNJ's Harbor Deepening Project NO_x Offset initiative, the emissions reduced through these upgrades can be utilized to offset emissions from other projects, such as Project 11 in POH, which involves dredging and harbor expansion.
- **Electrification of CHE** – The replacement of diesel engines on cargo handling equipment (CHE) with electric batteries effectively eliminates all engine emissions from these units. However, compared to repowering or replacing older diesel engines with cleaner alternatives, transitioning to battery powered CHE also entails the installation of charging facilities, which in themselves require a significant investment. As seen in Table 7, it may not be cost-effective to replace all CHE with battery-powered options (refer to CAAP - CHE Replacement). Nevertheless, specific instances, such as the Globalplex harbor cranes installation, demonstrate that selective replacement of CHE with battery-powered alternatives can be highly cost-effective. Therefore, the port needs to identify the CHE to be electrified based on factors such as installation and charging facility costs, as well as the potential for emissions reduction.

In addition to the Task 6 deliverable (this report), the TTI study team has developed an Excel-based tool to assist the TCEQ in evaluating the emissions reduction and cost

benefits of the recommended strategies. This tool utilizes default rates and values derived from the literature review conducted during the project. It is important to note that this Excel-based tool is not included in the project's deliverables.

Figure 10 shows the landing page of the Excel tool, which enables users to easily select the specific strategy they wish to focus on. Each strategy page, as demonstrated in Figure 11, provides a concise description of the strategy, including the equations utilized for the calculations. The tool includes an input section where users can enter their preferred parameters, such as fleet composition and upgrade population. Additionally, there is a default and fixed data section that allows users to review the predetermined values (users can modify default values if they possess local data). The tool also provides a calculation output section, displaying both the emission reduction (in tons per year) and the cost benefit (in $/ton). While there is a "Click here to download user guide" button, at present, a user guide for the Excel tool is not yet available. However, the TTI study team is prepared to develop one if the TCEQ project manager deems the tool valuable and intends to share it with other stakeholders. The user guide would provide detailed instructions and explanations on how to effectively utilize the Excel tool.

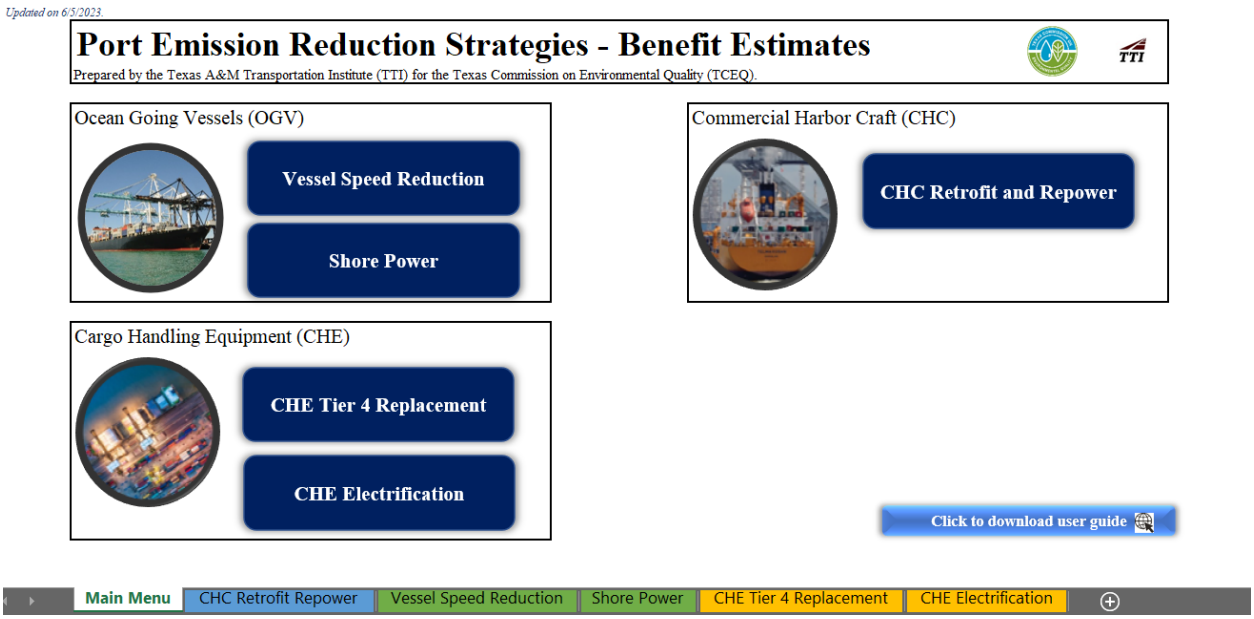
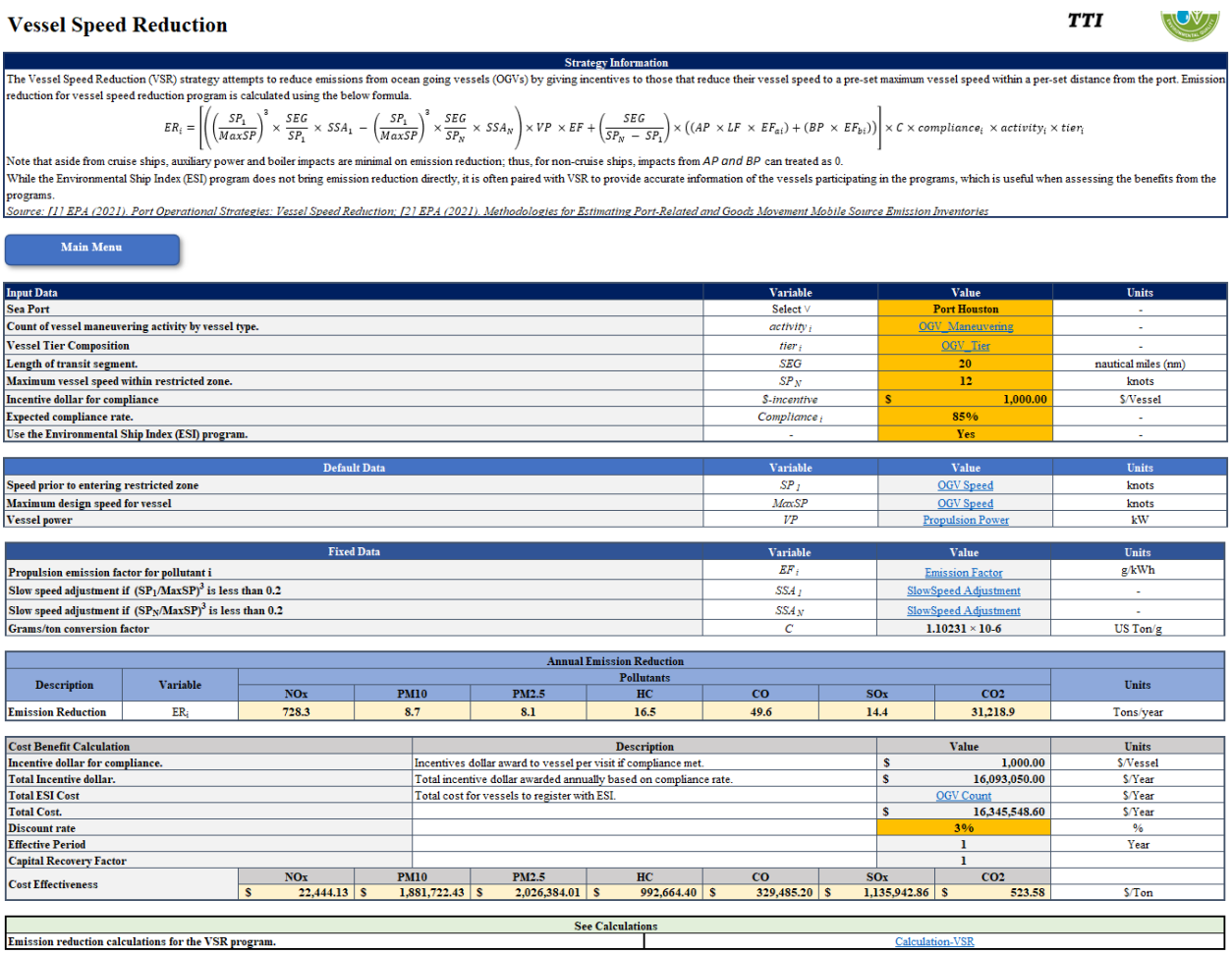


Figure 10. Snapshot of the Landing Page of the Excel Tool



Vessel Speed Reduction TTI

Strategy Information
The Vessel Speed Reduction (VSR) strategy attempts to reduce emissions from ocean going vessels (OGVs) by giving incentives to those that reduce their vessel speed to a pre-set maximum vessel speed within a per-set distance from the port. Emission reduction for vessel speed reduction program is calculated using the below formula.

$$ER_i = \left[\left(\left(\frac{SP_1}{MaxSP}\right)^3 \times \frac{SEG}{SP_1} \times SSA_1 - \left(\frac{SP_1}{MaxSP}\right)^3 \times \frac{SEG}{SP_N} \times SSA_N\right) \times VP \times EF + \left(\frac{SEG}{SP_N - SP_1}\right) \times ((AP \times LF \times EF_{ai}) + (BP \times EF_{bi}))\right] \times C \times compliance_i \times activity_i \times tier_i$$

Note that aside from cruise ships, auxiliary power and boiler impacts are minimal on emission reduction; thus, for non-cruise ships, impacts from *AP* and *BP* can treated as 0.
While the Environmental Ship Index (ESI) program does not bring emission reduction directly, it is often paired with VSR to provide accurate information of the vessels participating in the programs, which is useful when assessing the benefits from the programs.
Source: [1] EPA (2021). Port Operational Strategies: Vessel Speed Reduction; [2] EPA (2021). Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emission Inventories

Main Menu

Input Data	Variable	Value	Units
Sea Port	Select ∨	Port Houston	-
Count of vessel maneuvering activity by vessel type.	$activity_i$	OGV_Maneuvering	-
Vessel Tier Composition	$tier_i$	OGV_Tier	-
Length of transit segment.	SEG	20	nautical miles (nm)
Maximum vessel speed within restricted zone.	SP_N	12	knots
Incentive dollar for compliance	$-incentive	$ 1,000.00	$/Vessel
Expected compliance rate.	$Compliance_i$	85%	-
Use the Environmental Ship Index (ESI) program.	-	Yes	-

Default Data	Variable	Value	Units
Speed prior to entering restricted zone	SP_1	OGV Speed	knots
Maximum design speed for vessel	$MaxSP$	OGV Speed	knots
Vessel power	VP	Propulsion Power	kW

Fixed Data	Variable	Value	Units
Propulsion emission factor for pollutant i	EF_i	Emission Factor	g/kWh
Slow speed adjustment if $(SP_1/MaxSP)^3$ is less than 0.2	SSA_1	SlowSpeed Adjustment	-
Slow speed adjustment if $(SP_N/MaxSP)^3$ is less than 0.2	SSA_N	SlowSpeed Adjustment	-
Grams/ton conversion factor	C	1.10231 × 10-6	US Ton/g

Annual Emission Reduction									
Description	Variable	Pollutants							Units
		NOx	PM10	PM2.5	HC	CO	SOx	CO2	
Emission Reduction	ER_i	728.3	8.7	8.1	16.5	49.6	14.4	31,218.9	Tons/year

Cost Benefit Calculation	Description	Value	Units
Incentive dollar for compliance.	Incentives dollar award to vessel per visit if compliance met.	$ 1,000.00	$/Vessel
Total Incentive dollar.	Total incentive dollar awarded annually based on compliance rate.	$ 16,093,050.00	$/Year
Total ESI Cost	Total cost for vessels to register with ESI.	OGV Count	$/Year
Total Cost.		$ 16,345,548.60	$/Year
Discount rate		3%	%
Effective Period		1	Year
Capital Recovery Factor		1	

Cost Effectiveness	NOx	PM10	PM2.5	HC	CO	SOx	CO2	
	$ 22,444.13	$ 1,881,722.43	$ 2,026,384.01	$ 992,664.40	$ 329,485.20	$ 1,135,942.86	$ 523.58	$/Ton

See Calculations	
Emission reduction calculations for the VSR program.	Calculation-VSR

Figure 11. Snapshot of a Strategy Page on the Excel Tool.

All calculations in the Excel tool are calculated within the tool itself and do not require any connections to the Internet. By clicking on the hyperlinks, users can access hidden sheets with calculations and databases that provide more detailed information. These sheets were hidden to maintain clarity within the spreadsheet. The TTI study team has prepopulated the Excel tool with POH EI [41], and users can update the spreadsheet with emission indices from any port, provided that the source use type is consistently named as published here.

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APPENDIX A: LIST OF PRINCIPAL PORTS, THE TOTAL TONNAGE, AND NAAQS ATTAINMENT STATUS

This appendix contains the full list of ports that were initially reviewed by the TTI study team in Chapter 2.3.1.2.

List of Principal Ports, their Commodity Tonnage Summaries for 2020, and their Non-Attainment Status (Ranked by Total Tonnage in Descending Order)

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
1	Houston Port Authority, TX	2031	79,177,826	56,970,738	139,791,725	196,762,463	275,940,289	Houston-Galveston-Brazoria, TX	Ozone_8-hr (2015), Ozone_8-hr (2008)
2	South Louisiana, LA, Port of	2253	112,372,057	30,423,984	82,290,656	112,714,640	225,086,697	<Null>	
3	Corpus Christi, TX	2423	25,056,307	17,606,086	108,093,092	125,699,178	150,755,485	<Null>	
4	New York, NY & NJ	398	40,087,797	68,357,078	15,252,563	83,609,641	123,697,438	New York, NY-NJ-CT	Ozone_8-hr (2015), Ozone_8-hr (2008)
5	New Orleans, LA	2251	43,220,217	15,324,118	22,523,113	37,847,231	81,067,448	<Null>	
6	Port of Long Beach, CA	4110	13,490,353	46,552,104	19,135,630	65,687,734	79,178,087	Los Angeles-South Coast Air Basin, CA	Ozone_8-hr (2015), Ozone_8-hr (2008)
7	Port of Greater Baton Rouge, LA	2252	43,420,458	5,662,827	22,603,587	28,266,414	71,686,872	Baton Rouge, LA	Ozone_8-hr (2008)
8	Beaumont, TX	2393	24,785,761	16,170,960	29,610,665	45,781,625	70,567,386	<Null>	
9	Port of Los Angeles, CA	4120	4,501,365	38,658,365	16,292,409	54,950,774	59,452,139	Los Angeles-South Coast Air Basin, CA	Ozone_8-hr (2015), Ozone_8-hr (2008)
10	Virginia, VA, Port of	5700	4,956,369	12,362,773	40,729,643	53,092,416	58,048,785	<Null>	
11	Mobile, AL	2032	18,794,083	17,859,999	16,552,479	34,412,478	53,206,561	<Null>	
12	Plaquemines Port District, LA	2255	25,879,971	4,555,969	16,314,859	20,870,828	46,750,799	<Null>	
13	Port of Savannah, GA	776	1,135,777	24,505,366	17,811,901	42,317,267	43,453,044	<Null>	
14	Lake Charles Harbor District, LA	2248	20,333,504	5,026,406	17,693,748	22,720,154	43,053,658	<Null>	
15	Port Arthur, TX	2416	17,297,108	7,316,835	16,608,257	23,925,092	41,222,200	<Null>	
16	Port Freeport, TX	2408	4,171,925	6,560,377	28,016,360	34,576,737	38,748,662	Houston-Galveston-Brazoria, TX	Ozone_8-hr (2015), Ozone_8-hr (2008)
17	Mid-Ohio Valley Port, OH, and WV	2366	35,939,474	0	0	0	35,939,474	Parkersburg-Marietta, WV-OH	PM2.5 (1997)

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
18	Baltimore, MD	700	4,211,847	12,937,138	18,053,042	30,990,180	35,202,027	Baltimore, MD	Ozone_8-hr (2015), Ozone_8-hr (2008), PM2.5 (1997)
19	Cincinnati-Northern KY, Ports of	2338	34,476,340	0	0	0	34,476,340	Cincinnati, OH-KY-IN	Ozone_8-hr (2008), Ozone_8-hr (2015), PM2.5 (1997)
20	Texas City, TX	2428	12,540,971	7,601,309	13,579,032	21,180,341	33,721,312	Houston-Galveston-Brazoria, TX	Ozone_8-hr (2015), Ozone_8-hr (2008)
21	St. Louis Metro Port, IL and MO	2367	30,487,796	0	0	0	30,487,796	St. Louis, MO-IL	PM2.5 (1997), Ozone_8-hr (2015), Ozone_8-hr (2008)
22	Huntington-Tristate, KY, OH, WV	2348	29,699,657	0	0	0	29,699,657	Huntington-Ashland, WV-KY-OH	PM2.5 (1997)
23	Philadelphia Regional Port, PA	552	11,589,634	9,833,680	7,094,446	16,928,126	28,517,760	Philadelphia-Wilmington, PA-NJ-DE	PM2.5 (2006), PM2.5 (1997), Ozone_8-hr (2015), Ozone_8-hr (2008)
24	Tampa Port Authority, FL	2021	15,913,148	8,250,523	4,348,089	12,598,612	28,511,760	<Null>	
25	Valdez, AK	4816	23,019,746	0	2,093,485	2,093,485	25,113,231	<Null>	
26	Duluth-Superior, MN, and WI	3924	19,363,238	692,776	5,015,096	5,707,872	25,071,110	<Null>	
27	Port of Charleston, SC	773	1,822,973	14,996,099	8,128,410	23,124,509	24,947,482	<Null>	
28	Indiana (Northern District), IN	3743	24,128,574	512,759	42,727	555,486	24,684,060	Chicago, IL-IN-WI	Ozone_8-hr (2015), Ozone_8-hr (2008), PM2.5 (1997)
29	Jackson County Port, MS	2004	8,311,645	7,450,788	7,334,345	14,785,133	23,096,778	<Null>	
30	Seattle, WA	4722	4,814,772	9,098,134	9,051,640	18,149,774	22,964,546	<Null>	
31	Tacoma, WA	4720	4,186,844	5,794,811	11,593,404	17,388,215	21,575,059	<Null>	
32	Richmond, CA	4350	6,277,538	11,494,554	3,278,649	14,773,203	21,050,741	San Francisco Bay Area, CA	PM2.5 (2006), Ozone_8-hr (2015), Ozone_8-hr (2008)

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
33	Port of Portland, OR	4644	6,391,344	2,218,431	12,096,570	14,315,001	20,706,345	<Null>	
34	Port Everglades, FL	1911	11,177,768	6,498,551	2,764,254	9,262,805	20,440,573	<Null>	
35	South Jersey Port District, NJ	550	8,383,229	11,271,285	599,811	11,871,096	20,254,325	Philadelphia-Wilmington, PA-NJ-DE	PM2.5 (2006), PM2.5 (1997), Ozone_8-hr (2015), Ozone_8-hr (2008)
36	Port of Oakland, CA	4344	1,313,835	8,520,142	9,605,785	18,125,927	19,439,762	San Francisco Bay Area, CA	PM2.5 (2006), Ozone_8-hr (2015), Ozone_8-hr (2008)
37	Port of Kalama, WA	4626	1,393,416	328,888	16,418,582	16,747,470	18,140,886	<Null>	
38	Jacksonville, FL	2017	7,892,986	7,379,715	1,428,669	8,808,384	16,701,370	<Null>	
39	Pittsburgh, PA Port of	2358	15,536,051	0	0	0	15,536,051	Pittsburgh-Beaver Valley, PA	PM2.5 (2006), PM2.5 (1997), Ozone_8-hr (2008), PM2.5 (2012)
40	New Bourbon Port Authority, MO	2351	15,506,754	0	0	0	15,506,754	<Null>	
41	Mid-America Port, IA, IL, and MO	2306	14,952,343	0	0	0	14,952,343	<Null>	
42	Illinois Waterway Ports, IL	7713	14,946,034	0	0	0	14,946,034	<Null>	
43	Two Harbors, MN	3926	11,746,091	0	1,753,756	1,753,756	13,499,847	<Null>	
44	Boston, MA	149	3,399,778	8,310,101	1,612,703	9,922,804	13,322,582	<Null>	
45	Honolulu, O'ahu, HI	4420	11,424,582	619,948	216,976	836,924	12,261,506	<Null>	
46	Galveston, TX	2417	5,242,679	1,525,032	5,177,471	6,702,503	11,945,182	Houston-Galveston-Brazoria, TX	Ozone_8-hr (2015), Ozone_8-hr (2008)
47	Port of Longview, WA	4622	1,145,333	338,172	9,587,780	9,925,952	11,071,285	<Null>	
48	Port of Vancouver USA, WA	4636	2,557,938	1,128,602	6,512,062	7,640,664	10,198,602	<Null>	

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
49	Cleveland-Cuyahoga Port, OH	3217	7,655,827	1,359,394	427,518	1,786,912	9,442,739	Cleveland, OH	PM2.5 (2012), Ozone_8-hr (2015), PM2.5 (2006), PM2.5 (1997), Ozone_8-hr (2008)
50	San Juan, PR	1913	4,611,787	4,285,535	439,841	4,725,376	9,337,163	San Juan, PR	SO2 (2010)
51	Illinois International Port, IL	3749	7,218,634	1,827,750	44,701	1,872,451	9,091,085	Chicago, IL-IN-WI	Ozone_8-hr (2015), Ozone_8-hr (2008), PM2.5 (1997)
52	Toledo-Lucas County Port, OH	3204	4,343,925	1,853,372	2,852,141	4,705,513	9,049,438	<Null>	
53	Memphis-Shelby County Port, TN	2294	8,680,428	0	0	0	8,680,428	Memphis, TN-MS-AR	Ozone_8-hr (2008)
54	Joliet Regional Port, IL	7711	8,586,533	0	0	0	8,586,533	Chicago, IL-IN-WI	Ozone_8-hr (2015), Ozone_8-hr (2008), PM2.5 (1997)
55	PortMiami, FL	2164	191,258	5,385,323	2,822,104	8,207,427	8,398,685	<Null>	
56	E Iowa and W Illinois, IA IL	2350	8,352,916	0	0	0	8,352,916	<Null>	
57	Detroit-Wayne County Port, MI	3321	5,748,026	2,438,379	11,023	2,449,402	8,197,428	Detroit, MI	SO2 (2010)
58	New Haven, CT	1507	4,794,789	3,009,380	306,607	3,315,987	8,110,776	New York, NY-NJ-CT	PM2.5 (2006), PM2.5 (1997)
59	Louisville-Jefferson Port, KY	2333	8,069,320	0	0	0	8,069,320	Louisville, KY-IN	PM2.5 (1997), Ozone_8-hr (2015)
60	Nashville, TN	2370	7,540,444	0	0	0	7,540,444	<Null>	
61	Kalaeloa Barbers Point, HI	4458	2,411,595	4,924,376	155,460	5,079,836	7,491,431	<Null>	
62	Greater Lafourche Port, LA	1910	7,215,051	135,882	58,553	194,435	7,409,486	<Null>	
63	Port of Providence, RI	191	2,875,346	4,292,763	228,474	4,521,237	7,396,583	<Null>	
64	Conneaut, OH	3227	5,336,139	126,257	1,926,693	2,052,950	7,389,089	Cleveland-Akron-Lorain, OH	Ozone_8-hr (2008)
65	Anacortes, WA	4730	5,701,201	255,420	1,031,669	1,287,089	6,988,290	<Null>	
66	Brownsville, TX	2420	2,777,097	3,696,342	308,554	4,004,896	6,781,993	<Null>	

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
67	Wilmington, NC	766	530,248	3,308,754	2,509,688	5,818,442	6,348,690	<Null>	
68	Rogers City, MI	3635	6,045,224	57,956	18,298	76,254	6,121,478	<Null>	
69	Mount Vernon, IN	2332	5,938,469	0	0	0	5,938,469	<Null>	
70	Kaskaskia Regional Port, IL	2307	5,773,418	0	0	0	5,773,418	St. Louis, MO-IL	PM2.5 (1997), Ozone_8-hr (2015), Ozone_8-hr (2008)
71	Marquette, MI	3841	4,466,314	426,453	770,892	1,197,345	5,663,659	<Null>	
72	Wilmington, DE	554	727,138	3,269,426	1,575,220	4,844,646	5,571,784	Philadelphia-Wilmington, PA-NJ-DE	PM2.5 (2006), PM2.5 (1997)
73	Sabine Pass Port Authority, TX	2397	2,152,828	223,822	3,160,324	3,384,146	5,536,974	<Null>	
74	Southeast Missouri Port, MO	2368	5,105,607	0	0	0	5,105,607	<Null>	
75	Paducah-McCracken Riverport, KY	2302	5,004,903	0	0	0	5,004,903	<Null>	
76	St. Paul Port Authority, MN	2320	4,791,628	0	0	0	4,791,628	<Null>	
77	Calhoun Port Authority, TX	2427	2,621,886	481,723	1,656,834	2,138,557	4,760,443	<Null>	
78	Stockton, CA	4270	0	3,215,758	1,397,500	4,613,258	4,613,258	San Joaquin Valley, CA	PM2.5 (2006), PM2.5 (1997), Ozone_8-hr (2015), Ozone_8-hr (2008), PM2.5 (2012)
79	Albany Port District, NY	505	3,493,865	921,752	161,752	1,083,504	4,577,369	<Null>	
80	Canaveral Port District, FL	2160	1,106,268	3,425,265	9,243	3,434,508	4,540,776	<Null>	
81	Tulsa-Rogers County Port, OK	6109	4,458,282	0	0	0	4,458,282	<Null>	
82	Portland, ME	128	613,989	3,739,120	112	3,739,232	4,353,221	<Null>	
83	Silver Bay, MN	3928	4,020,409	0	314,812	314,812	4,335,221	<Null>	
84	Manatee County Port, FL	2023	1,090,529	2,901,421	249,298	3,150,719	4,241,248	<Null>	
85	Vicksburg, MS	2276	4,146,171	0	0	0	4,146,171	<Null>	

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
86	Orange County Nav District, TX	2398	4,094,719	96	0	96	4,094,815	<Null>	
87	Massac-Metropolis Port, IL	2316	3,864,840	0	0	0	3,864,840	<Null>	
88	Presque Isle Township, MI	3619	3,756,525	43,858	19,096	62,954	3,819,479	<Null>	
89	Ashtabula Port Authority, OH	3219	3,157,394	418,429	130,664	549,093	3,706,487	Cleveland-Akron-Lorain, OH	PM2.5 (1997), Ozone_8-hr (2008)
90	Mueller Township, MI	3803	3,472,305	54,114	74,296	128,410	3,600,715	<Null>	
91	Kahului, Maui, HI	4410	3,054,445	38,238	0	38,238	3,092,683	<Null>	
92	Port of Alaska, AK	4820	1,701,901	1,340,710	0	1,340,710	3,042,611	<Null>	
93	Grays Harbor Port District, WA	4702	56,430	116,632	2,736,883	2,853,515	2,909,945	<Null>	
94	Greenville, MS	2271	2,908,067	0	0	0	2,908,067	<Null>	
95	Central Louisiana Regional, LA	2227	2,846,161	0	0	0	2,846,161	<Null>	
96	Nikiski, AK	4831	2,471,028	344,972	18,713	363,685	2,834,713	<Null>	
97	Owensboro Riverport, KY	2331	2,810,704	0	0	0	2,810,704	<Null>	
98	Milwaukee, WI	3756	1,266,953	1,351,513	159,693	1,511,206	2,778,159	Milwaukee, WI	Ozone_8-hr (2015), PM2.5 (2006)
99	Portsmouth, NH	135	204,851	2,523,048	9,370	2,532,418	2,737,269	<Null>	
100	Marblehead, OH	3212	2,604,591	0	15,444	15,444	2,620,035	<Null>	
101	Port of Brunswick, GA	780	151,145	1,148,758	1,258,639	2,407,397	2,558,542	<Null>	
102	New Madrid County Port, MO	2288	2,442,759	0	0	0	2,442,759	New Madrid County, MO	SO2 (2010)
103	Alpena, MI	3617	2,278,659	130,120	0	130,120	2,408,779	<Null>	
104	Port Jefferson, NY	522	2,301,985	0	0	0	2,301,985	New York, NY-NJ-CT	PM2.5 (2006), PM2.5 (1997)
105	Clark Township, MI	3627	2,138,844	37,479	48,501	85,980	2,224,824	<Null>	

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
106	Port of Palm Beach District, FL	2162	775,969	353,102	1,059,610	1,412,712	2,188,681	<Null>	
107	San Francisco Port, CA	4335	1,109,600	1,040,321	38,760	1,079,081	2,188,681	San Francisco Bay Area, CA	PM2.5 (2006)
108	Ponce Port Authority, PR	2151	0	2,099,215	28,660	2,127,875	2,127,875	<Null>	
109	Guaynabo, PR	1912	248,994	1,720,688	72,385	1,793,073	2,042,067	San Juan, PR	SO2 (2010)
110	Panama City Port Authority, FL	2016	437,398	500,506	1,098,900	1,599,406	2,036,804	<Null>	
111	Victoria, TX	2399	2,032,848	0	0	0	2,032,848	<Null>	
112	Green Bay, WI	3778	1,411,271	611,129	0	611,129	2,022,400	<Null>	
113	Chattanooga, TN	2372	2,010,475	0	0	0	2,010,475	Chattanooga, AL-TN-GA	PM2.5 (1997)
114	Kawaihae, Hawai'i, HI	4405	1,969,829	0	0	0	1,969,829	<Null>	
115	Redwood City, CA	4340	45,352	1,676,157	212,849	1,889,006	1,934,358	San Francisco Bay Area, CA	PM2.5 (2006)
116	Hilo, Hawai'i, HI	4400	1,906,206	18,459	0	18,459	1,924,665	<Null>	
117	Terrebonne Parish Port, LA	2224	1,858,611	0	0	0	1,858,611	<Null>	
118	Oxnard Harbor District, CA	4150	15,176	1,706,547	122,459	1,829,006	1,844,182	Ventura County, CA	Ozone_8-hr (2015), Ozone_8-hr (2008)
119	Coos Bay OR, Port of	4660	42,829	184,643	1,608,052	1,792,695	1,835,524	<Null>	
120	Guntersville, AL	2371	1,824,997	0	0	0	1,824,997	<Null>	
121	Yabucoa, PR	2220	0	1,488,229	317,837	1,806,066	1,806,066	<Null>	
122	Nawiliwili, Kaua'i, HI	4431	1,776,755	12,726	0	12,726	1,789,481	<Null>	
123	Morehead City, NC	764	577,278	942,636	245,531	1,188,167	1,765,445	<Null>	
124	Henderson County Riverport, KY	2329	1,758,708	0	0	0	1,758,708	<Null>	
125	Sandusky, OH	3213	642,856	169,196	946,066	1,115,262	1,758,118	<Null>	
126	Port of Iberia District, LA	2030	1,692,226	0	0	0	1,692,226	<Null>	

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
127	Port of Harlingen Authority, TX	2402	1,658,124	0	0	0	1,658,124	<Null>	
128	Gulfport, MS	2083	27,587	1,094,440	520,696	1,615,136	1,642,723	<Null>	
129	Searsport, ME	112	95,174	1,528,105	18,357	1,546,462	1,641,636	<Null>	
130	Bridgeport, CT	311	1,604,244	15,362	0	15,362	1,619,606	New York-Northern New Jersey-Long Island, NY-NJ-CT	Ozone_8-hr (2015)
131	Grand Haven, MI	3728	1,192,329	405,565	0	405,565	1,597,894	<Null>	
132	Kansas City Port Authority, MO	2385	1,555,950	0	0	0	1,555,950	Jackson County, MO	SO2 (2010)
133	San Diego Unified Port, CA	4100	308,370	1,211,912	22,102	1,234,014	1,542,384	San Diego County, CA	Ozone_8-hr (2015), Ozone_8-hr (2008)
134	Alexandria-Cario Port, IL	2308	1,535,493	0	0	0	1,535,493	<Null>	
135	Port of Rosedale, MS	2259	1,532,545	0	0	0	1,532,545	<Null>	
136	Helena-West Helena Port, AR	2365	1,449,102	0	0	0	1,449,102	<Null>	
137	Monroe, MI	3202	1,335,848	52,517	0	52,517	1,388,365	Detroit, MI	Ozone_8-hr (2015), PM2.5 (2006), PM2.5 (1997)
138	Pemiscot County Port, MO	2263	1,328,867	0	0	0	1,328,867	<Null>	
139	Everett, WA	4725	1,001,492	250,015	32,087	282,102	1,283,594	<Null>	
140	Marine City, MI	3506	1,271,202	0	0	0	1,271,202	St. Clair, MI	SO2 (2010), Ozone_8-hr (2015), PM2.5 (2006), PM2.5 (1997)
141	Unalaska Island, AK	4947	266,339	391,570	582,994	974,564	1,240,903	<Null>	
142	Muskegon, MI	3725	661,757	522,927	33,045	555,972	1,217,729	<Null>	
143	Sacramento-Yolo Port, CA	4240	0	965,585	234,599	1,200,184	1,200,184	Sacramento, CA	PM2.5 (2006), Ozone_8-hr (2015), Ozone_8-hr (2008)
144	Kivalina, AK	4978	1,131,586	16,240	0	16,240	1,147,826	<Null>	
145	Hickman-Fulton County Port, KY	2304	1,129,707	0	0	0	1,129,707	<Null>	

Rank	Port Name, State	Port Number	Domestic	Imports	Exports	Foreign	Total	Nonattainment Area	Pollutant(s)
146	Lake Providence Port, LA	2269	1,120,845	0	0	0	1,120,845	<Null>	
147	Heartland Port Authority, MO	2353	1,076,933	0	0	0	1,076,933	<Null>	
148	Richmond, VA	737	1,020,355	0	55,988	55,988	1,076,343	<Null>	
149	Drummond Island, MI	3813	902,037	48,330	84,878	133,208	1,035,245	<Null>	
150	Lorain Port Authority, OH	3216	568,627	204,984	153,223	358,207	926,834	<Null>	

[1]Data retrieved from the Bureau of Transportation Statistics at https://geodata.bts.gov/datasets/usdot::principal-ports/about and the US Army Corps of Engineers digital library at https://usace.contentdm.oclc.org/digital/collection/p16021coll2/id/7447.
[2]Total Tonnage is the total of Domestic and Foreign, whereas Foreign is the total of Imports and Export.

APPENDIX B: LIST OF PORT CONTACTS

This Appendix contains a list of contact staff for each priority port (see Table 3), including names, titles, and contact information.

Contact List for each Port on the Priority List

Port	Name	Title	Phone	Email
Port of Houston, TX	Jason Ahn	Sustainability Program Manager	(713)-670-2447 (o) (346)-504-7958 (c)	jahn@porthouston.com
Port of South Louisiana, LA,	Brian Cox	Chief Operating Officer	(985)-652-9278 x1110	bcox@portsl.com
Port of Corpus Christi, TX	Sarah Garza	Director of Environmental Planning and Compliance (Committee member)	(361)-885-6163	sarah@pocca.com
Port of New York and New Jersey, NY and NJ	Christopher Zeppie Charles Liou	Director Office of Environmental Policy, Programs & Compliance Manager, Environmental Initiatives	(212)-435-4415 (212- 435-4431	czeppie@panynj.gov cliou@panynj.gov
Port of New Orleans, LA	Chris Gilmore Darlene Collins	Director of Engineering & Environmental Environmental Specialist	(504)-528-3305 (504)-528-3343	chris.gilmore@portnola.com darlene.collins@portnola.com
Port of Long Beach, CA	Heather Tomley Kezia Daniels Rick Cameron	Managing Director, Planning and Environmental Affairs Bureau Executive Assistant Deputy Executive Director of Planning and Development	(562)-283-7117 (562)-283-7066 (562)-283-7050	heather.tomley@polb.com kezia.daniels@polb.com(?) rick.cameron@polb.com
Port of Greater Baton Rouge, LA	Cortney White	Director of Engineering & Security	(225)-342-1660 ext. 1208	whitec@portgbr.com
Port of Beaumont, TX	Brandon Bergeron	Director of Engineering and committee member	(409)-835-5367	bmb@portofbeaumont.com
Port of Los Angeles, CA	David Libatique	Deputy Executive Director, Stakeholder Engagement	(310)-732-3905	dlibatique@portla.org
Port of Virginia, VA,	Cathie J. Vick	Chief Development & Public Affairs Officer	(757)-683-2105	cvick@portofvirginia.com

Port	Name	Title	Phone	Email
Port of Mobile, AL	Gretchen Barrera, PE	Environmental Section Manager and Committee member	(251)-441-7086	gretchen.barrera@alports.com
Plaquemines Port District, LA	Paul Matthews	Executive Director	(985)-652-9278	pmatthews@portsl.com
Port of Savannah, GA	Christopher B. Novack, P.E.	Senior Director of Engineering and Facilities Maintenance	(912)-964-3922	cnovack@gaports.com
Lake Charles Harbor District, LA	Regan Brown	Health, Safety, & Environmental Compliance Manager and Committee Member	(337)-493-3540	rbrown@portlc.com
Port Arthur, TX	Ed Long	Director of Engineering	(409)-983-201	bob.b@portofportarthur.com or bob@portofportarthur.com
Port Freeport, TX	Jason Hull	Director of Engineering	(800)-362-5743 x4322	hull@portfreeport.com
Port of Baltimore, MD	Bill Richardson	Gen. Mgr. of the Safety, Environmental, Risk Management Department	(410)-633-1145	wrichardson@marylandports.com
Texas City, TX	Ramiro Barba Remy Steffer	President Director of Engineering	(409)-945-4461	rbarba@tctrr.com rsteffer@tctrr.com
St. Louis Metro Port (St. Louis Development Corporation)	Neal Richardson	Chairman & Executive Director (SLDC)	(314)-657-3735	richardsonn@stlouis-mo.gov

APPENDIX C: DERA FUNDS DISTRIBUTION AT THE PRIORITY PORTS

This Appendix list the DERA funding history for each of the ports on the priority list (see Table 3), including the port name, the fiscal year where the DERA funds were granted, the project title and description, and the funding that was awarded. The information in this appendix was retrieved from the EPA's *Clean Air Practive at Ports Public Data* spreadsheet [28], available at: https://www.epa.gov/ports-initiative/best-port-wide-planning-practices-improve-air-quality#clean_air.

DERA Funding History for Ports on the Priority List

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of New York and New Jersey	2009	ARRA National	NESCAUM	Northeast States for Coordinated Air Use Management	$2,798,961	Repower two ferries and three tugboats with Tier 2 engines.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of New York and New Jersey	2009	ARRA National	Port Authority of NY&NJ Ports	The Port Authority of New York & New Jersey	$6,998,528	Replace 636 drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2009	ARRA National	Port Authority of NY&NJ Marine	The Port Authority of New York & New Jersey	$2,858,200	Install shore power at the Brooklyn Cruise Terminal.	Shore Power	Port Sector Only	N
Port of New York and New Jersey	2011	National	Repower of 21 Engines on Eight Marine Vessels Operating in New York Harbor and Vicinity	New Jersey Clean Cities Coalition	$858,524	Replace 21 engines on eight marine vessels to Tier 2 standards.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2012	National	Marine Engine Repower of Tugboat Coral Coast	CLF Ventures	$1,319,484	Repower 2 Tier 0 marine propulsion engines in one vessel with EPA Tier 3-certified engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2013	National	2013 DERA - Connecticut Maritime Foundation	Connecticut Maritime Foundation Inc.	$600,000	Repower one tug with two propulsion engines from Tier 0 to Tier 3.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2013	National	Repower of 6 Engines on Three Marine Vessels Operating in New York Harbor and Vicinity	New Jersey Clean Cities Coalition	$352,480	Repower two tugs and one supply vessel from Tier 0 to Tier 3 (6 engines).	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2014	National	2014 DERA - NJ CCC - Marine Repowers	New Jersey Clean Cities Coalition	$178,054	Repower seven marine vessels with 13 Tier 3 engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2014	Ports	2014 Ports DERA - New Jersey DEP	New Jersey Dept of Environmental Protection	$1,372,938	Replace four Tier 1 marine propulsion engines with Tier 4 certified engines.	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of New York and New Jersey	2015	National	2015 DERA - Port Authority of New York and New Jersey	The Port Authority of New York & New Jersey	$1,000,000	Replace 26 drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2016	National	2016 DERA - Regional Truck Replacement Program III	The Port Authority of New York & New Jersey	$1,787,554	Replace 72 drayage trucks with clean diesel-powered trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2016	National	2016 DERA - M/V Emerald Coast Marine Engine Repower	Connecticut Maritime Foundation Inc.	$507,546	Repower one marine vessel with two Tier 3 propulsion engines and two Tier 3 auxiliary gensets.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2017	National	Marine Ferry Engine Replacement	Connecticut Maritime Foundation Inc.	$864,907	Replace tug boat propulsion engines with Tier 3 engines	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2017	National	Truck Replacement Program	The Port Authority of New York & New Jersey	$1,750,000	Replace 70 port drayage trucks	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2018	National	Truck Replacement Program	The Port Authority of New York & New Jersey	$2,000,000	Replace 80 EMY 1996 through 2006 port drayage trucks with 80 newer port drayage trucks meeting EMY 2013 emission standards.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2019	National	Drayage Truck Replacement Program	The Port Authority of New York & New Jersey	$1,050,000	Replace 42 old drayage trucks with new diesel trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2019	National	New York Marine Ferry Engine Replacement	CLF Ventures	$809,819	Replace the propulsion and/or auxiliary engines in 5 vessels with Tier 3 engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2019	National	M/V Highlands Ferry Engine Replacement	Connecticut Maritime Foundation Inc.	$1,832,567	Replace Tier 1 propulsion and auxiliary generator set engines in a Ferry with Tier 3 engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2020	National	NYC Metro Marine Ferry Engine Replacement Project	Connecticut Maritime Foundation Inc.	$1,037,213	Replace the engines in a ferry vessel with 2 new diesel engines.	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of New York and New Jersey	2020	National	Red Hook Container Terminal: Tier 4 Terminal Tractor Replacement	The Port Authority of New York & New Jersey	$420,000	Replace 12 terminal tractors with new Tier 4 tractors.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2020	National	Drayage Truck Replacement Program	The Port Authority of New York & New Jersey	$1,250,000	Provide rebates for 50 drayage truck replacements.	Incentives	Port Sector Only	N
Port of New York and New Jersey	2009-2010	National	PANYNJ Supplemental Truck Replacement Program	The Port Authority of New York & New Jersey	$1,575,315	Replace 125 pre-2003 model-year drayage trucks with 2007-certified trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New York and New Jersey	2009-2010	National	NYC DOT Private Ferry Vessel Repower Project	New York City Department of Transportation	$2,000,000	Repower four main and two auxiliary engines on one commuter ferry with Tier 2-certified engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Baltimore	2012	National	2012 Mid-Atlantic Clean Diesel Assistance Program	Mid-Atlantic Regional Air Management Association Inc	$1,287,564	Repower marine vessel engines, and retrofit drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Baltimore	2013	Ports	2013 Ports DERA - Maryland Port Administration	Maryland Port Administration	$749,995	Replace 35 pre-1997 drayage trucks with new trucks powered by new certified engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Baltimore	2015	National	2015 DERA - Maryland Environmental Services	Maryland Environmental Service	$869,988	Replace 25 drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Baltimore	2016	National	2016 DERA - CARGO (Clean Air Recognition Grants & Opportunities)	Maryland Environmental Service	$965,926	Replace/Repower 26 pieces of cargo handling equipment; Install automatic start/stop idle reduction technology on five locomotives.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Baltimore	2017	National	Hybrid Shuttle Carrier Project	Virginia Port Authority	$2,000,000	Replace nine straddle carriers with clean diesel-powered hybrid cargo handling equipment	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Baltimore	2018	National	CARGO (Clean Air Recognition Grants & Opportunities)	Maryland Environmental Service	$2,453,952	Cargo handling equipment upgrades, replace 35 drayage trucks, propulsion and auxiliary engine replacement in marine vessel	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Baltimore	2019	National	CARGO-Clean Air Recognition Grants & Opportunities	Maryland Environmental Service	$2,037,316	Replace 4 cargo handling equipment and 64 drayage trucks with new diesel equipment	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Baltimore	2008, 2009, 2010, 2011	State	2008 - 2011 State DERA - Maryland	Maryland Department of the Environment	$957,775	Retrofit highway and nonroad vehicles with diesel particulate filters (DPF) and crankcase ventilation (CCV).	Equipment Upgrade/Replacement	Partial Port Sector	N
Port of Baltimore	2014, 2015, 2016	State	2014 - 2016 State DERA - Maryland	Maryland Department of the Environment	$436,285	Replace older Class 8 heavy duty short haul dray trucks	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Savannah	2008	National	Green CHE Fleet	Georgia Ports Authority	$250,000	Retrofit the entire fleet of cargo handling equipment (133 units) at the Savannah port with DOCs and CCVs.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Savannah	2009	ARRA National	GA Ports Authority	Georgia Ports Authority	$124,007	Install diesel oxidation catalysts (DOC) and closed crankcase ventilation (CCV) on 47 marine engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Savannah	2013	National	Drayage Truck Rebate Replacement Program	Georgia Ports Authority	$830,392	Replace 30 drayage trucks with SCR.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Savannah	2015	National	2015 DERA - Georgia Ports Authority	Georgia Ports Authority	$983,895	Replace 29 drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Savannah	2016	National	2016 DERA - Georgia Ports Authority Drayage Program	Georgia Ports Authority	$1,417,085	Replace 63 drayage trucks with clean diesel-powered trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Savannah	2017	National	Drayage Truck Rebate Replacement Program	Georgia Ports Authority	$1,100,000	Replace 37 drayage trucks with clean diesel-powered trucks	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Savannah	2020	National	Dray Truck Rebate Replacement Program	Georgia Ports Authority	$1,100,000	Replace 37 drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Savannah	2009-2010	National	Georgia Ports Authority	Georgia Ports Authority	$2,525,246	Retrofit 39 on-road and non-road public works vehicles with diesel particulate filters (DPFs).	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Mobile	2011	National	Alabama State Port Authority	Alabama State Port Authority	$953,921	Replace one locomotive engine.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Mobile	2012	National	ASPA Terminal Railway MP-15 Locomotive Repowers	Alabama State Port Authority	$1,350,000	Repower two locomotives.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Mobile	2014, 2015, 2016	State	2014 - 2016 State DERA - Alabama	Alabama Department of Environment Management	$428,518	Retrofit switch locomotive and transport refrigeration unit engine replacement	Equipment Upgrade/Replacement	Partial Port Sector	N
Port of Houston	2009	ARRA National	Port of Houston-Cargo Handling Equip.	Port of Houston Authority	$2,267,742	Replace/repower 96 marine engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Houston	2009	ARRA National	Port of Houston-Cargo Handling Marine Vessels	Port of Houston Authority	$584,190	Replace/repower 25 marine engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Houston	2009	ARRA Emerging Technology	Houston Advanced Research Center Marine Diesel Engine Upgrade	Houston Advanced Research Center	$1,556,733	Upgrade two marine vessel engines to Tier 1.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Houston	2009	ARRA Smartway Finance	Houston-Galveston Area Council (HGAC)	Houston-Galveston Area Council	$8,750,000	Establishes revolving loan program to help regional and short-haul owner-operators and related small businesses purchase and operate cleaner more fuel-efficient trucks	Incentives	Partial Port Sector	N
Port of Houston	2011	National	Houston -Galveston Area Council Marine Engine Repowers	Houston-Galveston Area Council	$940,852	Repower 3 marine vessels with Tier II marine engines.	Equipment Upgrade/Replacement	Port Sector Only	Y

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Houston	2014	National	2014 DERA - Port of Houston - Drayage Truck Program Expansion	Port of Houston Authority	$814,339	Replace 25 Class 8 drayage trucks with newer certified engines.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Houston	2014	Ports	2014 Ports DERA - Port of Houston Authority	Port of Houston Authority	$793,030	Replace 14 drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Houston	2017	National	A Fresh Fleet at Port Houston	Port of Houston Authority	$143,500	Replace diesel buses with clean diesel-powered vehicles	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Houston	2009-2010	National	Port of Houston Fuel Switch Program for Ocean-going Vessels	Port of Houston Authority	$1,487,908	Fuel switching to a low-sulfur fuel (less than or equal to 0.2 percent) for 21 ocean-going vessels that call on the Port of Houston.	Alternative Fuel	Port Sector Only	N
Port of New Orleans	2009	ARRA Emerging Technology	Houston Advanced Research Center Marine Diesel Engine Upgrade	Houston Advanced Research Center	$1,556,733	Upgrade two marine vessel engines to Tier 1.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of New Orleans	2012	National	SEMO Clean Diesel Project 2012-14	Southeast Missouri Regional Planning Commission	$1,452,136	Replace two engines on two Mississippi River push boats with new Tier 3-rated engines.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of New Orleans	2015	National	2015 DERA - Port of New Orleans	Port of New Orleans	$727,000	Replace 20 older model years (1993-2006) with 2011 or newer trucks, equipped with diesel particulate filters.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New Orleans	2020	National	Clean Truck Replacement Incentive Program (CleanTRIP)	Port of New Orleans Board of Commissioners	$1,240,247	Replace 34 drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of New Orleans	2014, 2015, 2016	State	2014 - 2016 State DERA - Louisiana	Louisiana Department of Environmental Quality	$389,630	Replace older Class 8 heavy duty short haul dray trucks	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Greater Baton Rouge	2009	ARRA Emerging Technology	Houston Advanced Research Center Marine Diesel Engine Upgrade	Houston Advanced Research Center	$1,556,733	Upgrade two marine vessel engines to Tier 1.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Corpus Christi	2011	National	Houston -Galveston Area Council Marine Engine Repowers	Houston-Galveston Area Council	$940,852	Repower 3 marine vessels with Tier II marine engines.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Corpus Christi	2009-2010	National	Port of Corpus Christi Locomotive Switch Engine Repower Project	Port of Corpus Christi Authority	$1,026,058	Repower existing 1,000 horsepower locomotive switch engine with two 700 horsepower GENSET engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Long Beach	2009	ARRA National	Port of Long Beach	City of Long Beach Harbor Department	$4,008,250	Replace, repower, or retrofit 118 pieces of cargo handling equipment.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Long Beach	2011	National	Port of Long Beach Equipment and Vessel Emission Reduction Project	City of Long Beach Harbor Department	$2,371,358	Replace one truck; retrofit 30 top handlers with diesel particulate filters; repower one work boat and one crew boat.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Long Beach	2012	National	Port of Long Beach Emission Reduction Projects	City of Long Beach Harbor Department	$1,344,146	Replace five-yard tractors and retrofit 11 rubber-tired gantry cranes with diesel particulate filters.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Long Beach	2014	National	2014 DERA: SCAQMD CNG Truck & School Bus Replacements	South Coast Air Quality Management District	$1,160,056	Replace 80 legacy diesel Class 8a trucks and seven legacy diesel Type D school buses with new vehicles powered by compressed natural gas (CNG) engines.	Equipment Upgrade/Replacement	Partial Port Sector	Y
Port of Long Beach	2015	National	2015 DERA - City of Long Beach Harbor Department	City of Long Beach Harbor Department	$1,346,895	Replace eight-yard tractors with all-electric automated guided vehicles.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Long Beach	2016	National	2016 DERA - City of Long Beach Harbor Department	City of Long Beach Harbor Department	$1,469,818	Replace 24-yard tractors with 20 electric yard tractors and four electric AGVs	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Long Beach	2016	National	2016 DERA - South Coast AQMD	South Coast Air Quality Management District	$523,809	Replace one diesel switch locomotive with a Tier 4 locomotive.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Long Beach	2017	National	Interstate Drayage Truck Replacement Pilot Project	South Coast Air Quality Management District	$1,050,000	Replace 10 the model year 2012 heavy-duty diesel drayage trucks with 2017 or newer trucks powered by CNG engines certified to meet the CARB's Optional Low NOx emission standard of 0.02 g/bhp-hr. The model year 2012 trucks will be transferred to Washington State to replace 10 older drayage trucks (model years 1995-2006), which will then be scrapped.	Equipment Upgrade/Replacement	Partial Port Sector	Y
Port of Long Beach	2017	National	Marine Engine Upgrade and Zero-Emissions Cargo Handling	City of Long Beach Harbor Department	$469,680	Replace 11 marine engines with Tier 3 engines; Replace three rubber-tired gantry crane engines with all-electric motors	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Long Beach	2018	National	Low NOx Drayage Truck Replacements	South Coast Air Quality Management District	$1,601,523	Replace 16 drayage trucks with Low Nitrogen Oxide (NOx) Compressed Natural Gas (CNG) trucks	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Long Beach	2018	National	Near-Zero Emissions Locomotive Replacement	South Coast Air Quality Management District	$719,500	Replace one switcher locomotive operating at Port of Long Beach, and send replaced locomotive to Mojave Desert Air Quality Management District to replace an older unit	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Long Beach	2018	National	Clean Diesel Funding Assistance Program	City of Los Angeles Harbor Department	$279,750	Replace one terminal sweeper and four engines on two tugboats	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Long Beach	2019	National	Port of Long Beach – Hybrid RTG, Crane, and Vessel Project	City of Long Beach Harbor Department	$1,500,000	Replace 3 RTG cranes with hybrid Tier 4 diesel-electric RTG cranes, replace the engine in a crane with a Tier 4, and replace the engines in a marine vessel with Tier 3s.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Long Beach	2009-2010	Emerging Technology	South Coast AQMD Advanced Maritime Emission Control System Project - Port of Long Beach	South Coast Air Quality Management District	$1,500,000	Retrofit auxiliary-engine exhausts of several at-berth ocean-going vessels at Ports of Los Angeles and Long Beach with the advanced maritime emission control system (AMECS).	Equipment Upgrade/Replacement	Partial Port Sector	N
Port of Long Beach	2009-2010	National	Harbor Craft and Cargo-Handling Equipment at the Port of Long Beach	City of Long Beach Harbor Department	$1,630,051	Repower three harbor vessels and one piece of cargo-handling equipment; retrofit four pieces of cargo-handling equipment at Port of Long Beach.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Los Angeles	2009	ARRA National	City of LA Harbor Dept.	City of Los Angeles Harbor Department	$1,699,520	Retrofit 27 vehicles including harbor vessels, trucks, sweepers, loaders, cranes, and forklifts.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Los Angeles	2013	Ports	2013 Ports DERA - Port of Los Angeles	City of Los Angeles Harbor Department	$273,546	Retrofit 14 pieces of cargo handling equipment with diesel particulate filters (DPF).	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Los Angeles	2014	National	2014 DERA: SCAQMD CNG Truck & School Bus Replacements	South Coast Air Quality Management District	$1,160,056	Replace 80 legacy diesel Class 8a trucks and seven legacy diesel Type D school buses with new vehicles powered by compressed natural gas (CNG) engines.	Equipment Upgrade/Replacement	Partial Port Sector	Y

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Los Angeles	2014	Ports	2014 Ports DERA - Port of Los Angeles Crane Replacement Project	City of Los Angeles Harbor Department	$1,323,266	Replace one diesel-powered crane with an all-electric, zero-emission crane.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Los Angeles	2016	National	2016 DERA - City of Los Angeles, Harbor Department: POLA	City of Los Angeles Harbor Department	$629,702	Repower three tugboat engines; Replace seven top picks; Replace 16-yard tractors; Replace one sweeper; Repower four heavy lifts	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Los Angeles	2017	National	Interstate Drayage Truck Replacement Pilot Project	South Coast Air Quality Management District	$1,050,000	Replace 10 the model year 2012 heavy-duty diesel drayage trucks with 2017 or newer trucks powered by CNG engines certified to meet the CARB's Optional Low NOx emission standard of 0.02 g/bhp-hr. The model year 2012 trucks will be transferred to Washington State to replace 10 older drayage trucks (model years 1995-2006), which will then be scrapped.	Equipment Upgrade/Replacement	Partial Port Sector	Y
Port of Los Angeles	2018	National	Low NOx Drayage Truck Replacements	South Coast Air Quality Management District	$1,601,523	Replace 16 drayage trucks with Low Nitrogen Oxide (NOx) Compressed Natural Gas (CNG) trucks	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Los Angeles	2018	National	Clean Diesel Funding Assistance Program	City of Los Angeles Harbor Department	$279,750	Replace one terminal sweeper and four engines on two tugboats	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Los Angeles	2019	National	Low NOx Heavy Duty Truck Replacements	South Coast Air Quality Management District	$2,289,581	Replace the model year 2014 diesel trucks with new low NOx trucks, and replace pre-2006 short-haul and drayage trucks with 2014 and later diesel trucks	Equipment Upgrade/Replacement	Partial Port Sector	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Los Angeles	2009-2010	Emerging Technology	Port of Los Angeles EcoCrane Project	City of Los Angeles Harbor Department	$731,292	Replace the diesel engine in one diesel rubber tired gantry crane with a Tier 3 generator and two battery packs.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Los Angeles	2009-2010	National	Flex-Grid System for Alternative Maritime Power at the Port of Los Angeles	City of Los Angeles Harbor Department	$1,212,838	Install a natural gas-powered shore-to-ship electrical connection system for berthed ocean-going vessels at the Port of Los Angeles.	Shore Power	Port Sector Only	N
Port of Virginia	2012	National	2012 Mid-Atlantic Clean Diesel Assistance Program	Mid-Atlantic Regional Air Management Association Inc	$1,287,564	Repower marine vessel engines, and retrofit drayage trucks.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Virginia	2012	National	Engine Repower of Marine Tug G.M. McAllister	Virginia Maritime Association	$1,206,569	Repower two unregulated marine propulsion engines in one tug boat with EPA Tier 3 certified engines.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Virginia	2013	Ports	2013 Ports DERA - Port of Virginia	Virginia Port Authority	$750,000	Replace three shuttle carriers with Tier 4 diesel-electric shuttles.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Virginia	2014	National	2014 DERA - MARAMA Drayage Project	Mid-Atlantic Regional Air Management Association Inc	$715,216	Provide incentives for early replacement of 19 drayage trucks.	Incentives	Port Sector Only	Y
Port of Virginia	2020	National	The Port of Virginia Hybrid Shuttle Carrier Project	Virginia Port Authority	$2,375,000	Replace 10 diesel straddle carriers with Tier 4 hybrid-powered equipment.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Virginia	2008, 2009, 2010, 2011	State	2008 - 2011 State DERA - Virginia	Virginia Department of Environmental Quality	$833,025	Retrofit short-haul trucks with DOCs and CCVs	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Virginia	2009-2010	National	Virginia Port Authority Dredging Repower Project	Virginia Port Authority	$719,135	Repower two main engines of one dredge vessel.	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Virginia	2014, 2015, 2016	State	2014 - 2016 State DERA - Virginia	Virginia Department of Environmental Quality	$447,132	Replace older Class 8 heavy-duty short-haul trucks	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Virginia	2017, 2018	State	2017 - 2018 State DERA - Virginia	Virginia Department of Environmental Quality	$496,405	Replace older Class 8 heavy-duty short-haul trucks	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Metropolitan St. Louis	2011	National	Heart of Illinois Regional Ports District	Heart of Illinois Regional Port District	$400,000	Repower six tug boats operating along Illinois and Mississippi rivers.	Equipment Upgrade/Replacement	Port Sector Only	Y
Port of Metropolitan St. Louis	2011	National	SEMO Clean Diesel Project	Southeast Missouri Regional Planning Commission	$494,978	Repower a Mississippi River push boat.	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Metropolitan St. Louis	2011	National	Breathe Easy Missouri	Missouri Department of Natural Resources	$947,338	Replace marine engines, replace switcher locomotive engines, retrofit municipal vehicles with a diesel oxidation catalyst, replace school buses, and replace material handling equipment	Equipment Upgrade/Replacement	Partial Port Sector	N
Port of Metropolitan St. Louis	2011	National	Clean Up Missouri	Missouri Department of Natural Resources	$999,460	Retrofit and repower locomotives in Southeast Missouri and retrofit and replace school buses	Equipment Upgrade/Replacement	Partial Port Sector	N
Port of Metropolitan St. Louis	2013	National	SEMO Clean Diesel Project 2013-14	Southeast Missouri Regional Planning Commission	$500,000	Repower two push boats from Tier 0 to Tier 3 (four engines).	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Metropolitan St. Louis	2014	State	2014 State DERA - Missouri	Missouri Department of Natural Resources	$134,215	Repower marine vessels engines	Equipment Upgrade/Replacement	Port Sector Only	N

Port Name	Fiscal Year	DERA Program	Project Title	Recipient Organization	DERA Funding	Project Description	Strategy Type	Sector Scope	Multi-port Project?
Port of Metropolitan St. Louis	2018	National	Osage Marine Clean Diesel Project	Southeast Missouri Regional Planning Commission	$365,545	Mississippi River workboat engine replacement	Equipment Upgrade/Replacement	Port Sector Only	N
Port of Metropolitan St. Louis	2014, 2015, 2016	State	2014 - 2016 State DERA - Illinois	Illinois Environmental Protection Agency	$739,210	Repower marine vessels engines	Equipment Upgrade/Replacement	Partial Port Sector	Y

APPENDIX D. QUESTIONNAIRES FOR THE PORT AUTHORITIES

This appendix records the questionnaires that the TTI team prepared for the POLA, POLB, and PANYNJ port authorities.

QUESTIONNAIRES FOR POLA

1. Cost of running the programs:
    a. The 2017 CAAP Preliminary cost estimate document estimated the cost to be $600,000 annually. To determine the current average annual incentives cost for running the ESI program in the past six years, could you please provide updated estimates?
    b. The 2017 CAAP Preliminary cost estimate document stated that the annual cost for the VSR program was $3 million. Are these early estimates still accurate? If not, could you please provide the average amount paid out in annual incentives?
    c. What are the funding sources for these programs?
2. Emissions reduction:
    a. How many vessels were in Tiers 0, 1, and II compared to Tiers III and IV that complied with the ESI and VSR programs in 2022?
    b. What methodology and data are used to estimate/quantify the emission reduction benefits from the ESI for individual pollutants, such as NOx, VOC, PM2.5, and CO2? Could you provide us with some details on the methods, or link us to a white paper with the documentation?
    c. What are the most current estimates for emission reduction from the ESI?
3. Timeline of implementing the programs:
    a. The 2017 CAAP document stated that the funding for the ESI and VSR programs were estimated for 18 years. Do these program sunset after 18 years?
4. Compliance/general perspective of the programs:
    a. Based on the posted annual compliance report, the compliance rate of the VSR program continues to increase, which indicates it is a successful and well-received program. Does the ESI program follow a similar trend?

   b. From the port authority's perspective, how is the public and operators' acceptance of these strategies? For example, are they generally favorable, are they satisfied with the distribution of incentive funds, etc.?
5. Lessons learned:
   a. Are there any details of the ESI and VSR programs, or their execution, that the port would change or do differently based on the lessons learned from executing the programs? What are some pitfalls others should avoid from the port's experience?
   b. Lastly, based on your experience, are there any new strategies that the port is implementing, or plans on implementing, that you would like to highlight, such as the ZE truck voucher program, clean truck fund rate, etc.? If so, could you provide a short description or link to the documentation? Have you received feedback on the public's perspective of these strategies?

QUESTIONNAIRES FOR POLB

1. Cost of running the programs:
   a. The 2017 CAAP Preliminary cost estimate document estimated the cost to be $1,000,000 annually. To determine the current average annual incentives cost for running the GSI program in the past six years, could you please provide updated estimates?
   b. The 2017 CAAP Preliminary cost estimate document stated that the annual cost for the VSR program was $3 million. Are these early estimates still accurate? If not, could you please provide the average amount paid out in annual incentives?
   c. What are the funding sources for these programs?
2. Emissions reduction:
   a. How many vessels were in Tiers 0, 1, and II compared to Tiers III and IV that complied with the ESI and VSR programs in 2022?
   b. What methodology and data are used to estimate/quantify the emission reduction benefits from the GSI for individual pollutant, such as NOx, VOC, PM2.5, and CO2? Could you provide us with some details on the methods, or link us to a white paper with the documentation?
   c. What are the most current estimates for emission reduction from the ESI?
3. Timeline of implementing the programs:

   a. The 2017 CAAP document stated that the funding for the ESI and VSR programs were estimated for 18 years. Do these programs sunset after 18 years?
4. Compliance/general perspective of the programs:
   a. Based on the posted annual compliance report, the compliance rate of the VSR program continues to increase, which indicates it is a successful and well-received program. Does the ESI program follow a similar trend?
   b. From the port authority's perspective, how is the public and operators' acceptance of these strategies? For example, are they generally favorable, are they satisfied with the distribution of incentive funds, etc.?
5. Lessons learned:
   a. Are there any details of the ESI and VSR programs, or their execution, that the port would change or do differently based on the lessons learned from executing the programs? What are some pitfalls others should avoid from the port's experience?
   b. Lastly, based on your experience, are there any new strategies that the port is implementing, or plans on implementing, that you would like to highlight, such as the ZE truck voucher program, clean truck fund rate, etc.? If so, could you provide a short description or link to the documentation? Have you received feedback on the public's perspective of these strategies?

QUESTIONNAIRES FOR PANYNJ

1. Regarding the cost of running the programs:
   a. The VSR program does not directly translate to financial incentives to vessel operators, instead, they are awarded additional 20 or 40 CVI scores. Since a 20 CVI score would easily allow the vessel to qualify for the next Tier, in your opinion, is it accurate to put a dollar value of $1,000 on a 20 CVI score?
   b. We would like to know the average amount of annual funding provided by PANYNJ for the CVI program and whether the annual funding cap of $1.5 million is consistently reached.
   c. Based on your experience with the CVI program, please inform us of its cost-effectiveness, and whether an increase in the funding cap to over $1.5 million would lead to a proportionally higher emissions reduction.

   d. What are the main funding sources for the CVI program?
   e. In a PANYNJ newsletter from 2021, it was stated that the port authority provided $20 million for offsetting NOx emissions resulting from the expansion of the Panama Canal, in addition to the $2 billion dredging project. Is this $20 million the cost of replacing the 36 tugs and ferries?
   f. What is the average engine power (kW) and model year of the 36 tugs and ferries replaced for offsetting the Panama Canal Expansion project?
2. Regarding emissions reduction:
   a. According to the *EPA's Port Operation Strategies: Vessel Speed Reduction* report from 2021, VSR accounted for the reduction of 598.5 tons of NOx, 7.1 tons of PM, and 15,626 tons of CO2e based on the 2018 PANYNJ emissions inventory. Please inform us if the port is still experiencing this level of emission reduction from VSR in 2022, or if the reduction has increased. In addition, are the equations shown in the EPA report the same ones that PANYNJ used to estimate reductions from its VSR program? If so, is there a report or white paper that documents the datasets or assumptions used?
   b. What methodologies and data were used to estimate and quantify the emission reduction benefits from the ESI program? Can you provide the methodology and/or link us to a white paper with the methods?
   c. What the most current estimates for emission reduction from the ESI program?
3. Regarding the timeline for implementing the programs:
   a. Please inform us if there is a sunset period for the CVI program, or if the port authority plans on supporting the program indefinitely. We would like to understand the reasoning to inform our analysis.
4. Regarding the compliance/general perspective of the programs:
   a. Please inform us if the PANYNJ's VSR program requiring a lower speed for compliance compared to similar programs in other parts of the country (i.e., 10 knots versus 12 knots) has affected the overall compliance, and how it has been received by the vessel operators.
   b. Are vessels that comply with the CVI strategies generally older (i.e., Tiers 0, I, and II) or newer-cleaner fleets (i.e., Tiers III and IV). What percentage of these vessels are generally older fleets versus newer ones?

   c. Please inform us of the number of vessels that comply with the CVI in 2022 and the corresponding percentage. Also, is this trend growing or shrinking?
5. Regarding the lessons learned:
   a. Please inform us if there are any details of the CVI programs (both the VSR and the ESI), or their execution, that the ports would change given your experience with the program, such as best practices and lessons learned.
   b. Please inform us if there have been any new cost-effective strategies to reduce emissions from OGV, harbor craft, and cargo handling equipment that the port authority is implementing or plans on implementing.

APPENDIX E. LOG OF CONTACTED AUTHORITIES

This appendix records the conversation that the TTI team had with the port authorities.

Port	Contact Name	Contact Email	Date	TTI Staff	Contact Methods	Status
POLA	David Libatique	dlibatique@portla.org	5/5/2023	Guo Quan Lim	Email	Lim sent the questionnaires as listed in Appendix D to Mr. Libatique. No response was received.
POLB	Heather Tomley	heather.tomley@polb.com	5/5/2023	Guo Quan Lim	Email	Lim sent the questionnaires as listed in Appendix D to Ms. Tomley. Ms. Tomley promptly responded to the email on 5/5/2023. She expressed her intention to internally coordinate with her teams to determine the most effective approach for gathering and sharing the information requested by the TTI team. Ms. Tomley assured us that she would follow up with us shortly after the internal discussions had taken place.
PANYNJ	Christopher Zeppie, Charles Liou	czeppie@panynj.gov, cliou@panynj.gov	5/5/2023	Guo Quan Lim	Email	Lim sent the questionnaires as listed in Appendix D to Mr. Zeppie and Mr. Liou. Mr. Liou responded to the email on 5/5/2023. He confirmed his availability to address the questions of the TTI team and proposed a Microsoft Teams call scheduled for 5/19/2023.

Port	Contact Name	Contact Email	Date	TTI Staff	Contact Methods	Status
PANYNJ	Charles Liou	cliou@panynj.gov	5/5/2023	Guo Quan Lim	Email	Lim sent a Microsoft Teams meeting invite to Mr. Liou, Mr. Madhusudhan Venugopal (TTI), and Mr. Jim Kruse (TTI) for 9:00 to 10:00 AM on 5/19/2023, which was accepted by Mr. Liou and Mr. Venugopal. Mr. Liou forwarded the meeting invite to Ms. Tanja Grzeskowitz (Environmental Programs Principal and Specialist at PANYNJ) on 5/16/2023.
POLB	Heather Tomley	heather.tomley@polb.com	5/12/2023	Guo Quan Lim	Email	Lim sent Ms. Tomley a email to follow up on her reply received on 5/5/2023. No response was received.
PANYNJ	Tanja Grzeskowitz	tgrzeskowitz@panynj.gov	5/19/2023	Guo Quan Lim, Madhusudhan Venugopal	Teams meeting	This meeting was summarised in Chapter 3.2.3.
PANYNJ	Tanja Grzeskowitz	tgrzeskowitz@panynj.gov	5/22/2023	Guo Quan Lim	Email	Lim sent an email to Ms. Grzeskowitz as a follow-up to the Teams meeting on 5/19/2023. The purpose of the email was to kindly remind her about the commitment she made during the meeting to provide the methodologies and data used to calculate the benefits from PANYNJ's CVI program to the TTI team.

Port	Contact Name	Contact Email	Date	TTI Staff	Contact Methods	Status
PANYNJ	Tanja Grzeskowitz	tgrzeskowitz@panynj.gov	5/30/2023	Guo Quan Lim	Email	Lim sent an another email to Ms. Grzeskowitz as a follow-up to the Teams meeting on 5/19/2023. The purpose of the email was to kindly remind her about the commitment she made during the meeting to provide the methodologies and data used to calculate the benefits from PANYNJ's CVI program to the TTI team. Ms. Grzeskowitz responded to the email on 5/30/2023. She conveyed that a contractor is compiling the data and she plans sending it over to the TTI team before 6/2/2023.
POLB	Heather Tomley	heather.tomley@polb.com	5/30/2023	Guo Quan Lim	Email	Lim sent Ms. Tomley a email to follow up on her reply received on 5/5/2023.