SAN PEDRO BAY PORTS

CLEAN AIR ACTION PLAN 2017

Preliminary Cost Estimates for Select Clean Air Action Plan Strategies

JULY 2017

PRELIMINARY COST ESTIMATES FOR SELECT 2017 CLEAN AIR ACTION PLAN STRATEGIES

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1.0 INTRODUCTION

This document summarizes estimated costs associated with implementation of select 2017 Clean Air Action Plan (CAAP) strategies for the Port of Los Angeles (POLA) and the Port of Long Beach (POLB) (together, "Ports").

This document is presented in the following sections: Cargo-Handling Equipment (CHE), Heavy Duty Vehicles (HDV), Ocean-Going Vessels (OGV), Capital Infrastructure, and Technology Advancement Program (TAP). Each section contains a discussion of CAAP Requirements, Assumptions, and Preliminary Cost Estimate.

In many cases, assumptions have been made to estimate the cost for technology that is not commercially available. These estimates are changeable and dependent on the assumptions assigned to them. The assumptions used in this analysis are highlighted throughout the report. EnSafe Inc. acknowledges that changes in the assumptions can have a dramatic impact on the estimated costs.

2.0 BACKGROUND

The CAAP is a joint initiative of the Ports to reduce emissions related to Port operations. The original CAAP was developed in coordination with the United States Environmental Protection Agency Region 9, the California Air Resources Board (CARB), and the South Coast Air Quality Management District, adopted in 2006 (Ports, 2006), and updated in 2010 (Ports, 2010). In the fall of 2016, the Ports released the CAAP Discussion Document, which outlines the proposed updates to the CAAP. The 2017 CAAP is pending final development. Consideration of the CAAP by the Boards of POLA and POLB is anticipated in 2017.

This document has been prepared to provide an estimate of the costs associated with the implementation of several major strategies proposed in the CAAP Discussion Document. At this time, the state of near-zero and zero-emission technology development varies. For some equipment types, zero-emission technologies are commercially viable and in use in Port operations. For other equipment types, zero-emission options do not exist. This variability in the emerging near-zero and zero-emission market creates large uncertainties in the costs of future equipment and related infrastructure. For this reason, this document provides ranges of costs tied to the proposed CAAP strategies rather than a single definitive calculation for each strategy. As each strategy moves ahead for formal adoption, the Ports will conduct more detailed and comprehensive analyses of the implementation costs.

This document analyzes costs associated with the following CAAP 2017 Update strategies:

- Transition to zero-emissions terminal equipment
- Transition to near-zero and zero-emissions heavy-duty trucks
- Up to 100 percent reduction in at-berth emissions from ships
- Incentive programs to encourage deployment of cleaner ships

Additionally, this document estimates the costs associated with technology development and demonstrations and the necessary infrastructure to support the strategies listed above.

Key Assumptions

The following are key assumptions utilized in this analysis:

- For near-zero and zero-emission technologies that are not commercially available, cost estimates have been included. Estimate generation is discussed further in respective source category sections.

- For near-zero and zero-emission CHE and HDV technologies for which a commercial pricing is not available, projection factors have been generated to estimate costs. These conversion factors were developed as ratios from available commercial pricing and are discussed further in respective source category sections.

- The analysis assumes terminal and Port operations remain the same or similar to existing conditions. No changes were assumed outside of those directly related to the introduction of near-zero and zero-emission equipment.

- This analysis does not include marine terminal costs resulting from implementation of the near-zero and zero-emission technology into ongoing terminal operations such as increased costs resulting from reduced productivity, lost revenue from repositioned cargo to other terminals during construction, or costs of phased construction.

- This analysis focuses only on the capital costs associated with equipment upgrades and does not evaluate ongoing operational or maintenance costs, which may differ, positively or negatively, compared to existing operational and maintenance costs.

- This analysis does not include cost estimates for fueling or charging infrastructure for heavy-duty trucks, which is likely to exist outside the Harbor Districts and throughout the region.

- The analysis does not assume equipment cost reductions resulting from economies of scale. Furthermore, estimates are based on costs in 2017; inflation and the “future cost of money” have not been included in this analysis. Further, this analysis does not project the year in which these costs might hit the operators or the Ports based on projected fleet turnover; the analysis only looks at costs at the end of full implementation.

- This analysis does not assume cost offsets from government-backed incentive programs.

In addition to these key assumptions, specific assumptions for each strategy are reported in their respective sections.

3.0 CARGO-HANDLING EQUIPMENT

The 2017 CAAP addresses CHE through a combination of strategies, most prominently, requirements for equipment replacement with zero-emission technologies in alignment with the state's impending regulation for up to 100 percent zero-emission CHE by 2030.

At this time, the state of zero-emission CHE development varies. For some CHE types, zero-emission technologies are already commercially viable and in use at the Ports. For other CHE types, zero-emission options do not currently exist.

The 2017 CAAP includes both near-term and long-term strategies for CHE replacement. Where zero-emission CHE technologies are commercially available, the 2017 CAAP introduces near-term strategies to accelerate deployment. Where zero-emission CHE options do not exist, or where longer lead times required for adoption are expected, the 2017 CAAP introduces implementation strategies with longer timeframes.

3.1 CAAP Requirements

For CHE, the 2017 CAAP proposes to support, and where possible accelerate, the state's efforts to achieve up to 100 percent zero-emissions cargo-handling equipment by 2030.

3.2 Assumptions

Estimated implementation costs associated with CHE replacement were developed under the following assumptions:

- Fleet replacement costs are exclusively attributable to the operators of Port terminals. This analysis assumes no expense to OGV operators, rail operators, or the Ports.

- This analysis assumes replacement of existing CHE with zero-emission technologies on a 1:1 basis (i.e., replace one diesel-fueled yard truck with one electric or fuel cell yard truck).

- This analysis relies on fleet inventories of CHE at POLA and POLB, compiled in 2015 (POLB, 2015a; POLA, 2015b). Tables 1 and 2 present engine characteristics of the inventoried CHE fleets at POLA and POLB, respectively.

Table 1
Cargo-Handling Equipment Fleet, Port of Los Angeles (2015)

Equipment	Engine Type	Count	Average Model Year
Yard Truck	Diesel	813	2010
Forklift	Propane	369	2000
Top Handler	Diesel	192	2009
Yard Truck	Propane	180	2007
Forklift	Diesel	122	2009
RTG Crane	Diesel	113	2008
Side Pick	Diesel	31	2007
Straddle Carrier	Diesel	28	2014
Truck	Diesel	18	2007
Yard Tractor	LNG	17	2010
Forklift	Gasoline	8	2011
Yard Tractor	Gasoline	2	2012
Total		***1,893***	

Table 2
Cargo-Handling Equipment Fleet, Port of Long Beach (2015)

Equipment	Engine Type	Count	Average Model Year
Yard Truck	Diesel	535	2009
Top Handler	Diesel	170	2007
Forklift	Propane	103	2003
Forklift	Diesel	92	2007
Yard Truck	Gasoline	85	2011
RTG Crane	Diesel	64	2006
Forklift	Gasoline	14	2013
Side Handler	Diesel	14	2004
Tractor	Propane	9	1995
Forklift	Electric	9	2003
Truck	Diesel	8	2003
Yard Truck	Propane	7	2009
Truck	Electric	5	2008
Tractor	Diesel	1	2009
Total		***1,116***	

- Electric equipment that is currently in use at the Ports is assumed to not require replacement.

- For zero-emission CHE options that are commercially available, commercial price estimates were compiled from vendor quotes. Details of specific values are provided in the footnotes of Table 4.

- For zero-emission CHE options for which a commercial pricing is not available, cost estimates have been generated from projection factors. Projection factors have been calculated as follows:

  — Projection of the Cost for Electric vs Diesel — This value is the average ratio of known electric CHE commercial prices to known diesel-fueled CHE commercial prices for equivalent equipment.

  — Projection of the Cost for Fuel Cell vs Electric — This value is the average of known fuel cell CHE commercial prices to known electric CHE commercial prices.

Projection factors are presented in Table 3.

Table 3
Projection Conversion Factors — Cargo Handling Equipment

Projection of the Cost for Electric versus Diesel	Projection of the Cost for Fuel Cell versus Electric
2.4	1.6

3.3 Cost Estimate

Table 4 presents cost estimates of CHE. Where available, low-end and high-end estimates are presented.

Tables 5 and 6 present the estimated costs to upgrade the POLA and POLB CHE fleets, respectively, to comply with zero-emissions standards in accordance with the 2017 CAAP. The following costs are presented:

- Baseline Fleet Cost: Total cost of Port fleet as the cleanest available diesel equipment (i.e., Tier 4). This value is presented as a reference for Fleet Costs and Incremental Fleet Costs.

- Electric Equipment Fleet Cost: Total cost of replacing all Port CHE with electric equipment. CHE identified as already being zero-emissions are excluded from calculated replacement costs.

- Electric Equipment Incremental Fleet Cost: Difference between Electric Equipment Fleet Cost and New Diesel Fleet Cost.

- Fuel Cell Equipment Fleet Cost: Total cost of replacing all Port CHE with fuel cell equipment. CHE identified as already being zero-emissions are excluded from calculated replacement costs.

- Fuel Cell Equipment Incremental Fleet Cost: Difference between Fuel Cell Equipment Fleet Cost and New Diesel Fleet Cost.

- Low-End: Sum of lowest CHE cost estimates presented in Table 4.

- High-End: Sum of highest CHE cost estimates presented in Table 4.

Table 4
Unit Cargo-Handling Equipment Cost Estimates

Equipment	Tier 4 Diesel Equipment Cost		Retrofit — Electric Equipment Cost		Electric Equipment Cost		Fuel Cell Equipment Cost	
	Low End	High End	Low End	High End	Low End	High End	Low End	High End
Yard Truck	$125,000[1]	$125,000[1]	--	--	$250,000[2]	$300,000[2]	$350,000[3]	$420,000[3]
Top Handler	$520,000[1]	$600,000[1]	--	--	$1,600,000[4]	$1,800,000[4]	$2,520,000[3]	$2,520,000[3]
Forklift	$40,000[1]	$40,000[1]	--	--	$45,000[5]	$45,000[5]	$70,000[6]	$70,000[6]
RTG Crane	$1,300,000[1]	$1,300,000[1]	$425,000[1, 7]	$425,000[1, 7]	$2,500,000[1]	$2,500,000[1]	$3,500,000[3]	$3,500,000[3]
Side Pick	$315,000[1]	$600,000[1]	--	--	$1,600,000[8]	$1,800,000[8]	$2,520,000[3]	$2,520,000[3]
Straddle Carrier	$1,100,000[1]	$1,100,000[1]	--	--	$2,500,000[2]	$2,500,000[2]	$3,500,000[3]	$3,500,000[3]
Truck	$130,000[9]	$165,000[10]	--	--	$300,000[11]	$400,000[11]	$420,000[3]	$560,000[3]

[1] Estimate provided in *Technology Assessment: Mobile Cargo Handling Equipment* (CARB, 2015).
[2] Estimate based on vendor quotes from a previously submitted Energy Commission grant application at POLB for a BYD Motor, Inc. electric yard truck.
[3] Calculated using Fuel Cell vs Electric Projection Conversion Factor.
[4] Estimate based on vendor quotes from a previously submitted Proposition 1B grant applications at POLB.
[5] Estimate provided in *Potential Economic Impacts of Modifications to the "No VDECS Available" Compliance Extension for Mobile Cargo Handling Equipment Operating at Ports and Intermodal Rail Yards* (CARB, 2012).
[6] Estimated provided in *Economics of Fuel Cell Solutions for Material Handling* (Ballard, 2014).
[7] Estimate provided in *Technology Assessment: Mobile Cargo Handling Equipment* (CARB, 2015) is $250,000. A separate estimate provided in a Proposition 1B grant application at POLB was $600,000. This analysis assumes the average of these two values.
[8] Cost is assumed as top handler equivalent.
[9] Estimate of new diesel truck provided in *Zero Emission White Paper* (POLA, 2015).
[10] Estimate provided by Kenworth on March 15, 2017.
[11] Estimate provided by Transportation Power, Inc. on March 14, 2017.

Table 5
Estimate Cost of Cargo-Handling Equipment Replacement, Port of Los Angeles

Tier 4 Diesel Equipment Cost		Electric Equipment Fleet Cost		Electric Equipment Incremental Fleet Cost		Fuel Cell Fleet Cost		Fuel Cell Equipment Incremental Fleet Cost	
Low End	**High End**	**Low End**	**High End**	**Low End**	**High End**	**Low End**	**High End**	**Low End**	**High End**
$436,600,000	$461,500,000	$990,200,000	$1,087,200,000	$553,600,000	$625,700,000	$1,583,200,000	$1,738,500,000	$1,146,600,000	$1,277,000,000

Table 6
Estimate Cost of Cargo-Handling Equipment Replacement, Port of Long Beach

Baseline Fleet Cost		Electric Equipment Fleet Cost		Electric Equipment Incremental Fleet Cost		Fuel Cell Fleet Cost		Fuel Cell Equipment Incremental Fleet Cost	
Low End	**High End**	**Low End**	**High End**	**Low End**	**High End**	**Low End**	**High End**	**Low End**	**High End**
$265,100,000	$283,000,000	$625,500,000	$694,900,000	$360,400,000	$411,900,000	$1,000,200,000	$1,111,400,000	$735,100,000	$828,400,000

4.0 HEAVY-DUTY VEHICLES

The 2017 CAAP addresses HDVs through updates to the Clean Trucks Program. The updated Clean Trucks Program introduces a combination of HDV control measures, including requirements for truck replacements, and incentives for operation of cleaner trucks.

Where cleaner technologies and certified engines are already commercially available, the 2017 CAAP introduces near-term strategies to accelerate deployment. Where technologies are not commercially available, or where longer lead times required for adoption are expected, the 2017 CAAP introduces strategies with longer timeframes.

4.1 CAAP Requirements

The 2017 CAAP amends the Clean Trucks Program to encourage turnover to near-zero trucks and ultimately zero-emission trucks through incentives, fees, and requirements.

4.2 Assumptions

Estimated implementation costs associated with HDVs were developed under the following assumptions:

- Fleet replacement costs are exclusively attributable to the operators of drayage fleets. This analysis assumes no expense to the Ports or Ports terminal operators.
- This analysis relies on radio frequency identification based terminal gate activity data provided to the Ports by PierPass, Inc. In 2016, 17,504 unique HDV trucks were identified in service at the Ports. Table 7 provides a breakdown of unique HDV trucks identified in the 2016 calendar year by fuel type.

Table 7
Fuel Type Distribution of Ports Drayage Service Fleet (2016)

Fuel Type	Number of Unique Trucks Identified	Percent
Diesel	16,807	96.02%
CNG	26	0.15%
LNG	597	3.41%
LNG/Diesel	70	0.40%
Electric	2	0.01%
Other	2	0.01%
Total	***17,504***	***100%***

Notes:
CNG = Compressed Natural Gas
LNG = Liquefied Natural Gas

- 11.9-Liter (L) Low Nitrogen Oxide (NOx) trucks are not commercially available. Based on conversations with various representatives of the natural gas industry, EnSafe estimates the cost of an 11.9-L Low NOx truck to range from $195,000 to $225,000.

- Electric trucks capable of drayage service are not commercially available. This analysis utilizes a cost projection provided by a prototype manufacturer. Transportation Power, Inc. (TransPower), a manufacturer of electric trucks, reported an estimated cost between $400,000 and $600,000 per unit (TransPower, 2017). This analysis assumes the middle of this range, $500,000.

- For zero-emission truck options, for which commercial pricing is not available, cost estimates have been generated from Projection Factors. Projection Factors have been calculated as follows:

Projection of the Cost for Fuel Cell versus Electric — This value is the average of known fuel cell technology commercial prices to known electric commercial prices for similar equipment. Projection factors are presented in Table 8.

Table 8
Projection Conversion Factors – Heavy Duty Vehicles

Projection of the Cost for Fuel Cell vs Electric
1.6

4.3 Cost Estimate

Table 9 presents the estimated unit costs of truck replacement.

Table 9
Estimated Unit Costs for Heavy Duty Vehicles

Diesel Model Year 2010		Low NOx		Electric		Fuel Cell	
Low End	High End	Low End	High End	Low End	High End	Low End	High End
$130,000[12]	$165,000[13]	$190,000[14]	$225,000[14]	$300,000[15]	$400,000[15]	$480,000[16]	$640,000[16]

[12] Estimate of new diesel truck provided in *Zero Emission White Paper* (POLA, 2015).
[13] Estimate provided by Kenworth on March 15, 2017.
[14] Estimate for 11.9-L Low-NOx trucks was developed from reported costs of commercially available 11.9-L diesel and 8.9-L low-NOx truck pricing, as enumerated in Section 4.2.
[15] Estimate provided by Transportation Power, Inc. on March 14, 2017.
[16] Calculated using Fuel Cell vs Electric Projection Conversion Factor.

Table 10 presents the estimated cost to upgrade the Ports drayage fleet to comply with near-zero emissions standards and zero-emissions standards in accordance with the 2017 CAAP. The following costs are presented:

- Baseline Fleet Cost: Total cost of drayage fleet as diesel equipment. This value is presented as a reference for Fleet Costs and Incremental Fleet Costs. It is assumed that current natural gas trucks would be replaced with new natural gas trucks under this scenario.

- Electric Equipment Fleet Cost: Total cost of replacing all drayage trucks with electric vehicles.

- Electric Equipment Incremental Fleet Cost: Difference between Electric Equipment Fleet Cost and New Diesel Fleet Cost.

- Fuel Cell Equipment Fleet Cost: Total cost of replacing all drayage service trucks with fuel cell vehicles.

- Fuel Cell Equipment Incremental Fleet Cost: Difference between Fuel Cell Equipment Fleet Cost and New Diesel Fleet Cost.

- Low-NOx Equipment Fleet Cost: Total cost of replacing all drayage service trucks with natural gas equipment.

- Low-NOx Equipment Incremental Fleet Cost: Difference between Low-NOx Equipment Fleet Cost and New Diesel Fleet Cost.

Table 10
Estimate Costs of Heavy-Duty Vehicle Replacement

Diesel (2010) Fleet Cost		Electric Equipment Fleet Cost		Electric Incremental Fleet Cost		Fuel Cell Fleet Cost		Fuel Cell Incremental Fleet Cost		Low-NOx Fleet Cost		Low-NOx Incremental Fleet Cost	
Low End	High End	Low End	High End	Low End	High End	Low End	High End	Low End	High End	Low End	High End	Low End	High End
$2,323,800,000	$2,912,100,000	$5,250,600,000	$7,000,800,000	$2,926,800,000	$4,088,700,000	$8,401,100,000	$11,201,300,000	$6,077,300,000	$8,289,200,000	$3,325,300,000	$3,938,100,000	$1,001,500,000	$1,026,000,000

5.0 OCEAN-GOING VESSELS

The 2017 CAAP addresses emissions related to OGVs through a combination of strategies, including updates to incentive programs, changes to rate structures for older vessels, and inducements for use of berth emission capture and treatment systems (commonly referred to as "bonnet" systems) in support of and in alignment with the state's impending regulation for up to 100 percent at-berth controls by 2030.

5.1 CAAP Requirements

The 2017 CAAP introduces the following strategies related to OGVs:

- Modifications to the Environmental Ship Index program at POLA.
- Modifications to the Green Ship Incentive Program at POLB.
- Modify the Vessel Speed Reduction Program to expand compliance out to 40 nautical miles and to maximize emission reductions with differential speeds.
- Expand the use of at-berth emission capture and treatment systems for vessels calling at non-container terminals through incentives or lease requirements.

5.2 Assumptions

Estimated implementation costs associated with incentive programs were developed under the following assumptions:

- All descriptions of incentive programs and estimated costs of implementation were provided by the Ports.
- Program costs are exclusively attributable to the Ports. This analysis assumes no expense to the OGV, rail, or Ports terminal operators.
- For at-berth emission reduction technologies, this analysis draws upon information related to the state-approved bonnet systems. It is possible that other types of emission-control technologies may emerge over the next few years; however, projecting costs for systems that have not yet been developed is highly speculative. Thus, "bonnet system" is used more generally here to refer to any at-berth emission-control technology. This analysis assumes the following with regard to bonnet systems:

— This analysis assumes a cost of $6,000,000 per bonnet system. This estimate is based on the California Air Resources Board's Proposition 1B Final 2015 Guidelines for Implementation (CARB, 2015), as well as costs of currently available systems. Available systems that are potentially viable in the Ports are developed by Clean Air Engineering-Maritime, Inc. and Advanced Maritime Emissions Control Systems.

— Container terminals at the Ports will not require bonnet systems. Use of extant shore power systems is assumed.

— Cruise ship terminals at the Ports will not require bonnet systems. Use of extant shore power systems is assumed.

— One bonnet system will be dedicated to each liquid bulk terminal.

— For non-container, non-liquid bulk terminals, inventories of each Port were evaluated to estimate the number of non-container ship calls per day. A barge-based bonnet system is assumed to have the capacity to service multiple terminals. This analysis assumes a maximum number of non-container ship calls per day and a conservative number of required bonnet systems.

— The operational costs of bonnet systems, which may include chemical consumables, labor, and tug rental fees, are not assessed.

5.3 Cost Estimate

Tables 11 and 12 present the estimated costs of incentive program upgrades through 2035 for POLA and POLB, respectively, in accordance with the 2017 CAAP.

Table 11
Cost Estimate of Incentive Programs, Port of Los Angeles

Program Type	Cost Per Year	Years Until 2035	Total Incentive Costs Through 2035
Vessel Speed Reduction Program	$3,000,000	18	$54,000,000
Environmental Ship Index Program	$600,000	18	$10,800,000
Total			***$64,800,000***

Table 12
Cost Estimate of Incentive Programs, Port of Long Beach

Program Type	Cost Per Year	Years Until 2035	Total Incentive Costs Through 2035
Vessel Speed Reduction Program	$3,000,000	18	$54,000,000
Green Ship Incentive Program	$1,000,000	18	$18,000,000
Total			***$72,000,000***

Tables 13 and 14 present the estimated costs for the purchase of bonnet systems at POLA and POLB.

Table 13
Cost Estimate of Berth Emission Capture and Treatment Systems, Port of Los Angeles

Berth	Number of Bonnet Systems	Cost Per Bonnet System	Total Cost
Berths 118-120 Kinder Morgan Terminals	1	$6,000,000	$6,000,000
Berths 148-151 Phillips 66	1		$6,000,000
Berth 163 NuStar Energy L.P.	1		$6,000,000
Berth 164 Valero/Ultramar Inc.	1		$6,000,000
Berths 167-169 Shell Oil Products	1		$6,000,000
Berths 187-190 Vopak Terminals	1		$6,000,000
Berths 238-240C PBF Energy	1		$6,000,000
Non-Container Terminals	4		$24,000,000
Berths 91-93 World Cruise Center/Ports America Cruise Inc.	--		--
Berths 100-109 China Shipping North America/WBCT	--		--
Berths 121-131 Yang Ming Marine Transport/WBCT	--		--

Table 13
Cost Estimate of Berth Emission Capture and Treatment Systems, Port of Los Angeles

Berth	Number of Bonnet Systems	Cost Per Bonnet System	Total Cost
Berths 136-147 TraPac, Inc.	--		--
Berths 206-209 Port of Los Angeles/Pasha Stevedoring & Terminals	--		--
Berths 212-225 Yusen Terminals Inc.	--		--
Berths 226-236 Everport Terminal Services/STS	--		--
Berths 302-305 Eagle Marine Services, Ltd.	--		--
Berths 401-404 APM Terminals Pacific	--		--
Berths 405-406 California United Terminals	--		--
Total Cost			***$66,000,000***

Table 14
Cost Estimate of Berth Emission Capture and Treatment Systems, Port of Long Beach

Berth	Number of Bonnet Systems	Cost Per Bonnet System	Total Cost
Pier D Berths D32 CEMEX USA	—	$6,000,000	—
Pier F Berth F209 Chemoil Marine Terminal	1		$6,000,000
Pier B Berths B82, B83 Petro-Diamond/Toyota Logistics Services	1		$6,000,000
Pier B Berths B76-B80 Tesoro Logistics Operations LLS	1		$6,000,000
Pier B Berths B84-B87 Tesoro Logistics Operations LLS	1		$6,000,000
Pier T Berth T121 Tesoro Logistics Operations LLS	1		$6,000,000
Pier S Berth S101 Vopak Terminal Long Beach Inc.	1		$6,000,000
Non-Container Terminals	6		$36,000,000
Pier T Berths 130-140 TTI	—		—
Pier G Berths G226-G236 International Transportation Service	—		—
Pier F Berths F6-10 Long Beach Container Terminal	—		—
Pier J Berths J243-J247, J266-J270 Pacific Container Terminal	—		—
Pier A Berths A88-A96 SSA Terminals	—		—
Pier C Berths C60-C62 SSA Terminals	—		—
Total Cost			***$72,000,000***

6.0 CAPITAL INFRASTRUCTURE

Deployment of electrical equipment will require the installation of compatible and accessible electrical charging infrastructure. The 2017 CAAP introduces uniform infrastructure standards to enable the deployment of electric equipment on a large scale.

The 2017 CAAP standards will require upgrades to existing capital infrastructure, including rail infrastructure expansions at both Ports and electrical charging infrastructure at port terminals. This section includes a discussion of estimated costs.

6.1 CAAP Requirements

- Transitioning up to 100 percent zero-emissions terminal equipment by 2030.

- This cost estimate includes the following rail infrastructure expansions:

  — Port of Los Angeles

    - Pier 400 Storage Tracks Expansion — Addition of five storage tracks for use by APM Terminals, Inc.

    - Densification of Pier 400 Intermodal Container Transfer Facility (ICTF) — Addition rail mounted gantry (RMG) crane infrastructure and additional loading tracks with shortened track spacing.

    - Densification of West Basin Container Terminal ICTF — Addition of RMG crane infrastructure and additional loading tracks with closer track spacing.

    - West Basin Lead Track Gap Closure — Addition of a second main line railroad track along Harry Bridges Boulevard

    - Berth 200 Rail Yard and Track Connections Enhancements — Addition of drainage collection system for fueling facility and protection/relocation of Los Angeles Department of Water and Power water lines.

    - Berths 212-224 ICTF Expansion — Addition of one loading railroad track, one turnout, and backland reconstruction.

    - Upgrade of the at-grade rail crossing protection system for Anaheim Street rail crossing of McFarland lead track.

- — Port of Long Beach
    - Pier G Metro Track & Wharf Improvements
    - Double Track Access from Pier G to Pier J
    - Terminal Island Wye Rail Improvements
    - Pier B On-Dock Rail Support Facility

6.2 Assumptions

- Capital electrification costs are referenced from the *Preliminary Engineering Study for Electrification of Terminal Equipment at Port of Long Beach* (POLB, 2017). Referenced cost estimates include:

    - — Electrical infrastructure requirements for yard tractors, top handlers, and RTG cranes.

    - — The costs to bring additional electrical power down to the terminals to support the increased demand, which will likely be borne by the utility providers, estimated at $40,000,000 per container terminal.

    - — The costs to bring additional electrical power down to the terminals to support the increased demand, which will likely be borne by the utility providers, estimated at $1,000,000 per non-container terminal.

        - The Middle Harbor terminal at POLB will not require utility upgrades since electrical charging infrastructure is already in place.

        - The TraPac terminal at Port of POLA will require $20,000,000 in utility upgrades since some electrical charging infrastructure is already in place.

- Cost estimates for required infrastructure related to side picks, straddle carriers, and trucks are assumed to be the same as those of top handlers, RTG cranes, and yard trucks, respectively.

- For ancillary equipment, cost estimates were generated from energy consumption ratios. For each CHE type, operational voltage requirements were compared to those of yard tractors. This voltage requirement ratio was extrapolated to the unit infrastructure requirements of a yard tractor to generate an estimate unit infrastructure cost for each ancillary CHE type (POLB, 2017). This methodology was used to determine unit cost estimates for forklifts, man lifts, material handlers, loaders, sweepers, bulldozers, and other miscellaneous equipment.

- Specific rail improvement projects at POLA and POLB and associated cost estimates were provided by their respective Ports.

- This analysis does not include cost estimates for hydrogen fueling infrastructure, although portions of the cargo-handling equipment could transition to fuel cell. At this time, those costs are too speculative to include.

6.3 Cost Estimate

Tables 15 and 16 present the estimated costs of rail infrastructure improvement projects that support the strategy in the 2017 CAAP.

Table 15
Estimate of Rail Infrastructure Improvement Project Costs, Port of Los Angeles

Program Type	2016 Budget
Pier 400 Storage Tracks Expansion – addition of 5 storage tracks for use by APMT	$29,000,000
Densification of Pier 400 ICTF – adding RMG crane infrastructure and additional loading tracks with shortened track spacing	$60,000,000
Densification of WBCT ICTF – adding RMG crane infrastructure and additional loading tracks with closer track spacing	$50,000,000
West Basin Lead Track Gap Closure – addition of a second main line railroad track along Harry Bridges Boulevard	$8,900,000
Berth 200 Rail Yard and Track Connections Enhancements – addition of drainage collection system for fueling facility and protection/relocation of Department of Water and Power water lines	$3,000,000
Berths 212-224 Intermodal Container Transfer Facility Expansion — addition of one loading railroad track, one turnout, backland reconstruction	$6,500,000
At-Grade Rail Crossing Protection System for Anaheim St. Rail Crossing of McFarland Lead Track – upgrade the existing at-grade rail crossing protection system	$500,000
Total	***$157,900,000***

Notes:
APMT = APM Terminals Pacific, Ltd.
ICTF = Intermodal container transfer facility

Table 16
Estimate of Rail Infrastructure Improvement Project Costs, Port of Long Beach

Program Type	2016 Budget
Pier G Metro Track & Wharf Improvements	$15,600,000
Double Track Access from Pier G to Pier J	$25,000,000
Terminal Island Wye Rail Improvements	$27,000,000
Pier B On-Dock Rail Support Facility	$820,000,000
Total	***$887,600,000***

Tables 17 and 18 present the estimated costs of capital infrastructure upgrades for charging of electric CHE.

Table 17
Estimate of Electric Cargo Handling Equipment Infrastructure Costs, Port of Los Angeles

Equipment Type	Count	Electric Infrastructure Cost Per Unit	Electric Infrastructure Cost
Yard Truck	1,012	$344,000[17]	$348,100,000
Top Handler	192	$1,636,000[17]	$314,100,000
RTG Crane	113	$1,810,500[17]	$204,600,000
Side Pick	31	$1,636,000[18]	$50,700,000
Straddle Carrier	28	$1,810,500[19]	$50,700,000
Truck	18	$344,000[20]	$6,200,000
Forklift	499	$132,400[21]	$66,100,000
Man Lift	16	$1,800[21]	$30,000
Material Handler	12	$6,900[21]	$100,000
Loader	13	$4,900[21]	$100,000
Miscellaneous	7	$600[21]	$4,000
Sweeper	7	$1,500[21]	$10,000
Bulldozer	3	$1,100[21]	$3,000
Total			***$1,040,747,000***

Note:
RTG = Rubber tired gantry

[17] Estimate provided in *Preliminary Engineering Study for Electrification of Terminal Equipment at Port of Long Beach* (POLB, 2017).
[18] Cost is assumed as top handler equivalent.
[19] Cost is assumed as RTG crane equivalent.
[20] Cost is assumed as yard truck equivalent.
[21] Cost estimate generated from energy consumption ratios, as compared to yard truck.

Table 18
Estimate of Electric Cargo Handling Equipment Infrastructure Costs, Port of Long Beach

Equipment Type	Count	Electric Infrastructure Cost Per Unit	Electric Infrastructure Cost
Yard Truck	627	$339,000[17]	$212,600,000
Top Handler	170	$1,424,000[17]	$242,100,000
RTG Crane	64	$1,360,000[17]	$87,000,000
Side Pick	14	$1,424,000[18]	$19,900,000
Truck	13	$339,000[20]	$4,400,000
Tractor	10	$339,000[20]	$3,400,000
Forklift	218	$76,300[21]	$16,600,000
Loader	10	$7,300[21]	$100,000
Sweeper	12	$5,900[21]	$100,000
Man Lift	6	$1,100[21]	$10,000
Rail Pusher	3	$1,600[21]	$5,000
Miscellaneous	3	$100[21]	$300
Material handler	3	$4,000[21]	$10,000
Bulldozer	2	$800[21]	$2,000
Excavator	2	$1,800[21]	$4,000
Skid Steer Loader	1	$100[21]	$100
Total			***$586,227,300***

Tables 19 and 20 present the estimated costs of bringing additional electrical power down to the terminals in accordance with the requirements of the 2017 CAAP.

Table 19
Estimate of Electrical Charging Infrastructure Upgrade Costs, Port of Los Angeles

Terminal	Terminal Utility Upgrade Cost
Berth 46 Port of Los Angeles	$1,000,000
Berths 54-55 SSA Pacific, Inc.	$1,000,000
Berths 91-93 World Cruise Center/Ports America Cruise Inc.	$1,000,000
Berth 95 Catalina Sea and Air Terminal	$1,000,000
Berths 100-109 China Shipping North America/WBCT	$40,000,000
Berths 118-120 Kinder Morgan Terminals	$1,000,000
Berths 121-131 Yang Ming Marine Transport/WBCT	$40,000,000
Berths 136-147 TraPac, Inc.	$20,000,000
Berths 148-151 Phillips 66	$1,000,000
Berth 154-155 Port of Los Angeles/Pasha Stevedoring & Terminals	$1,000,000
Berth 163 NuStar Energy L.P.	$1,000,000

Table 19 Estimate of Electrical Charging Infrastructure Upgrade Costs, Port of Los Angeles	
Terminal	**Terminal Utility Upgrade Cost**
Berth 164 Valero/Ultramar Inc.	$1,000,000
Berths 165-166 Rio Tinto Minerals	$1,000,000
Berths 167-169 Shell Oil Products	$1,000,000
Berths 174-181 Pasha Stevedoring & Terminals	$1,000,000
Berths 187-190 Vopak Terminals	$1,000,000
Berth 191 Vopak Terminals/California Portland Cement	$1,000,000
Berths 195-199 WWL Vehicle Services Americas	$1,000,000
Berths 206-209 Port of Los Angeles/Pasha Stevedoring & Terminals	$1,000,000
Berths 210-211 SA Recycling, LLC	$1,000,000
Berths 212-225 Yusen Terminals Inc.	$40,000,000
Berths 226-236 Everport Terminal Services/STS	$40,000,000
Berths 238-240C PBF Energy	$1,000,000
Berth 301 Millennium Maritime Inc.	$1,000,000
Berths 302-305 Eagle Marine Services, Ltd.	$40,000,000
Berths 401-404 APM Terminals Pacific	$40,000,000
Berths 405-406 California United Terminals	$40,000,000
Total	***$319,000,000***

Note:
WBCT = West Basin Container Terminal

Table 20 Estimate of Electrical Charging Infrastructure Upgrade Costs, Port of Long Beach	
Terminal	**Terminal Utility Upgrade Cost**
Pier T Berths 130-140 TTI	$40,000,000
Pier G Berths G226-G236 International Transportation Service	$40,000,000
Pier F Berths F6-10 Long Beach Container Terminal	$0
Pier D-F, Berths 22, 24, 26 Middle Harbor	$0
Pier J Berths J243-J247, J266-J270 Pacific Container Terminal	$40,000,000
Pier A Berths A88-A96 SSA Terminals	$40,000,000
Pier C Berths C60-C62 SSA Terminals	$40,000,000
Pier D Berth D46 G-P Gypsum	$1,000,000
Pier F Berth F211 Koch Carbon	$1,000,000
Pier G Berth G212-G215 Metro Ports	$1,000,000
Pier F Berth F208 Mitsubishi Cement	$1,000,000
Pier F Berth F210 Morton Salt	$1,000,000
Pier B Berths B82 National Gypsum	$1,000,000
Pier T Berth T118 SA Recycling, LLC	$1,000,000

Table 20
Estimate of Electrical Charging Infrastructure Upgrade Costs, Port of Long Beach

Pier D Berths D32 CEMEX USA	$1,000,000
Pier F Berth F209 Chemoil Marine Terminal	$1,000,000
Pier B Berths B82, B83 Petro-Diamond/Toyota Logistics Services	$1,000,000
Pier B Berths B76-B80 Tesoro Logistics Operations LLS	$1,000,000
Pier B Berths B84-B87 Tesoro Logistics Operations LLS	$1,000,000
Pier T Berth T121 Tesoro Logistics Operations LLS	$1,000,000
Pier S Berth S101 Vopak Terminal Long Beach Inc.	$1,000,000
Pier F Berths F204 — F207 Crescent Terminal (SSA)	$1,000,000
Pier D Berths D50-D54 Crescent Warehouse Company	$1,000,000
Pier T Berth T122 Fremont Forest Products	$1,000,000
Standby Berth — Pier F Berth F201 Port of Long Beach	$1,000,000
Total	***$219,000,000***

7.0 TECHNOLOGY ADVANCEMENT PROGRAM

The TAP, a CAAP initiative, is a collaborative partnership among the Ports, regulatory agencies, and industry partners, including shipping lines and terminal operators.

7.1 CAAP Requirements

In the 2017 CAAP, the Ports envision specifically targeting TAP investments toward technologies for harbor craft, ships, and zero-emissions cargo-handling equipment as well as for operational approaches.

7.2 Assumptions

- Future TAP expenditures will be budgeted at $1,500,000 per year until 2025. Thereafter, until 2035, the maximum annual expenditure is expected to be $1,000,000 per year. These expenditures are inclusive of both Ports.

- TAP expenditures are at the discretion of the Ports and are subject to the availability of viable TAP projects and partners that meet the Ports' qualifications.

7.3 Cost Estimate

Table 21 presents the estimated costs of TAP expenditures in accordance with the requirements of the 2017 CAAP.

Table 21
Estimate of Technology Advancement Program Costs, Port of Los Angeles and Port of Long Beach

Cost Per Year	Years	Total TAP Cost
$1,500,000	2017-2025	$12,000,000
$1,000,000	2025-2035	$10,000,000
Total Cost by 2035		***$22,000,000***

8.0 NEXT STEPS

This document provides a preliminary estimate of the potential costs associated with select CAAP strategies and is not intended to be a thorough analysis of CAAP implementation costs.

As the Ports move forward with implementing CAAP 2017, the Ports will conduct more detailed and comprehensive cost assessments for each strategy. These detailed assessments may consider the following:

- Updates to per-unit costs of equipment and/or estimates for fueling infrastructure based on new information and studies, including future cost projections for fully commercialized equipment that does not exist today
- Inclusion of operational and maintenance costs
- Distribution of costs among the various industry partners (i.e., how costs may be borne by the Ports, private industry partners, and utility providers)
- Evaluation of when expenditures may occur based on fleet turnover and CAAP requirements
- Outcomes of feasibility assessments conducted for cargo-handling equipment and heavy-duty trucks

Additionally, the Ports may estimate costs associated with CAAP strategies not evaluated here.

9.0 REFERENCES

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