REPORT

Report: The Feasibility of Zero-Emissions Container Handling Equipment and the Feasibility of Related Goals and Metrics. **(Engineering)**

MEETING DATE:	12/12/2019
SUBMITTED BY:	Richard Sinkoff, Director of Environmental Programs & Planning
APPROVED BY:	Danny Wan, Executive Director

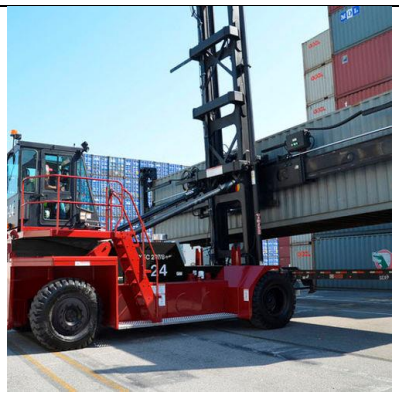
INTRODUCTION

On June 13, 2019, the Board of Port Commissioners ("Board") approved the Seaport Air Quality 2020 and Beyond Plan – The Pathway to Zero Emissions (the "2020 and Beyond Plan") by Resolution 19-41. At that time, and as documented in Resolution 19-41, the Board directed Port of Oakland ("Port") staff to submit agenda reports to the Board within six months of the date of the Resolution on:

1. The feasibility of replacing all cargo handling equipment ("CHE") at the Port with zero-emissions equipment including the feasibility of related goals and metrics ("CHE Study");
2. The feasibility of replacing all drayage trucks at the Port with zero-emissions trucks including the feasibility of related goals and metrics ("Zero-Emissions Drayage Truck Feasibility Study", or "Drayage Truck Study"); and
3. The capacity of the Seaport's electrical system, tenant needs for electric vehicle charging equipment, and the ability of the Port to provide electric vehicle charging equipment ("Electrical Capacity Study").

Each of these studies supports strategies and goals of the 2020 and Beyond Plan. The CHE Study supports Strategy #2: *Promote the Pathway to Zero Emissions Equipment and Operations*.

All cargo at the Port of Oakland is containerized. Most CHE is used at the Port's four marine terminals, but some equipment is also used in ancillary support (off-dock) areas. The major types of CHE are shown and described below as well as the number of pieces of equipment operating on the marine terminals (335) and off-dock (44).

Types and Approximate Numbers of Cargo Handling Equipment	
Yard tractors Move containers horizontally within yards. Also called hostlers or yard goats. On marine terminals, a chassis called a "bomb cart[1]" is attached to a yard tractor to transport import containers from ship to shore cranes to the yard. 200 on-dock 25 off-dock	
Top handlers Lift and stack loaded containers. 80 on-dock 5 off-dock	
Side handlers Lift and stack empty containers. 29 on-dock 14 off-dock	
Rubber Tired Gantry ("RTG") Cranes Used on marine terminals to stack import containers for pickup by drayage trucks. 26 on-dock	

[1] The name "bomb cart" refers to the sound during off-loading of containers from vessels.

Generally, equipment owners operate CHE off-road (within yards in the marine terminals or off-dock) and (except for some yard tractors) CHE are not street legal. CHE are primarily fueled by diesel or gasoline. A few off-dock yard tractors are battery electric, and all (13) RTG cranes at the Oakland International Container Terminal are being retrofitted from diesel to hybrid-electric engines[2]. To date, start-up company, OrangeEV, is the manufacturer of the only electric yard tractors in revenue service at the Seaport, but competitor start-up company, BYD, recently demonstrated its battery electric yard tractor at Port tenant, GSC's premises, and Port staff have been in discussions with the distributor of Kalmar, a long time original equipment manufacturer, regarding its electric yard tractor.

CONTEXT

The Port's 2020 and Beyond Plan focuses on advancing feasible and attainable near-term emission reduction measures with a long term goal of a zero-emissions Seaport. Appendix F of the 2020 and Beyond Plan included a Seaport equipment feasibility study which was the basis for the Port's approved goal of 44 electric yard tractors by 2025 on the marine terminals. As instructed by the Board, this informational report evaluates the feasibility of additional zero emission CHE goals.

EMISSIONS BENEFITS

Transitioning to zero-emissions CHE will reduce Diesel Particulate Matter and Greenhouse Gases as discussed below

Diesel Particulate Matter

The pollutant of highest concern for West Oakland is DPM because it is an airborne toxin known to increase cancer risk for individuals exposed to it regularly. According to the Port's 2017 emissions inventory[3], DPM emissions from CHE decreased 93% from 21.2 tons in 2005 to 1.6 tons in 2017 even as cargo volume grew by 6.5% total, largely due to fleet turnover to newer models with lower emitting engines. In 2017, CHE contributed 3% of the Seaport's DPM emissions.

CARB adopted a "Mobile CHE at Ports and Intermodal Rail Yards" regulation in 2005 as amended in 2011 which requires:

a. All newly purchased CHE used in port operations must have either a Tier 4 off-road engine or a model year 2010 or newer on-road engine;

[2] Port tenant, SSA, operates seven hybrid RTG cranes, and anticipates retrofitting all 13 in early 2020. Personnel communication with Ken Larson, November 2019. All ship to shore cranes are electric.
[3] https://www.portofoakland.com/files/PDF/Port_Oakland_2017_Emissions_Inventory.pdf

b. All CHE with Tier 3 and older engines to have a Level 3 Verified Diesel Emission Control Strategy installed one year after purchase;
c. Equipment owners must conduct annual opacity testing, maintain records, and report annually to CARB.

In March 2017, CARB's Board adopted Resolution 17-8 directing CARB staff to develop a new CHE regulation requiring up to 100% zero-emission CHE at ports and intermodal railyards by 2030. In March 2018, CARB updated its timeframe to consider this proposed regulation to 2022, with potential implementation in 2026 or later[4].

Greenhouse Gases

In 2017, CHE contributed 17% of the Seaport's CO2 equivalent ("CO2e") emissions[5]. Battery-electric CHE are as clean as the electrical grid. The Port's energy portfolio currently consists of 38% renewable and 17% carbon-free sources[6]. California's electric grid must be at least 44% renewable by 2024 to comply with the State's Renewable Portfolio Standard.

ZERO-EMISSION CHE FEASIBLITY ANALYSIS

The 2020 and Beyond Plan established a set of seven criteria to assess whether a clean air action is feasible: commercial availability, operational feasibility, affordability, exposure reduction, cost-effectiveness, acceptability, and need.

Port staff applied these criteria to zero-emissions battery electric CHE and determined that the primary challenges of zero-emissions CHE relate to commercial availability, operational feasibility and affordability. Other issues relate to lack of battery-electric charging standards, operating duration between charges, conformity to existing operating needs, electrical infrastructure cost, and the relatively low volume of CHE manufactured. Note that another zero emission option is CHE powered by hydrogen fuel, but this technology is in the early demonstration phase.

The following describes the commercial availability, operational feasibility and affordability of the major types of CHE to be transitioned to near zero and zero-emissions technology.

Commercial Availability:

Electric Yard Tractors: On-dock and off-dock yard tractors are at different levels of commercial availability. A few Orange EV electric yard tractors are in revenue service off-dock in Oakland. However, this and other battery electric models may not be suitable for

[4] CARB, Update on Concepts to Minimize the Community Health Impacts from Large Freight Facilities, Advance Materials (Revised), March 14, 2018.
[5] Port of Oakland, 2017 Seaport Air Emissions Inventory, Table 8-2b.
[6] Personnel communication with Jared Carpenter, Port Utility Business Administrator, November 2019. Percentages are 2019 to date.

marine terminal environments. On-dock models are best described as in "early commercial" stages[7]. They have not yet been proven reliable under daily operating conditions at a seaport for a range of duty cycles and heavy load conditions such as two 20-foot containers.

Hybrid or Electric Top and Side Handlers: No models are available through US service providers for any hybrid or electric models, but prototypes are available in European markets through original equipment manufacturers such as TopLift Ferrari, mainly for side handlers. Hybrids may be an appealing interim near zero emission step in advance of full electric model availability[8].

Hybrid RTGs are commercially available.

Electric RTGs are commercially available but have not been deployed in the west coast.

Operational Feasibility:

Electric Yard Tractors – Off-Dock: Electric yard tractors are in use at the Port of Oakland and in the City of Oakland-owned portion of the former Oakland Army Base. However, even off-dock, there can be operational issues including ability to get electrical permits to operate, and adequate electrical capacity.

Electric Yard Tractors – On-Dock: Current concerns include whether yard tractors can pull bomb carts carrying two loaded twenty foot equipment units (TEUs) from ship to shore cranes, and the need for inductive (wireless) versus manual charging to be compatible with ILWU agreements regarding labor classifications who can fuel versus operate equipment. SSA will demonstrate five electric yard tractors at the Matson Terminal in 2020/2021 as part of a CARB grant which will inform terminal operators regarding these and other questions including:

- Will models last through a full two-shift duty cycle?
- Will models last through a third (3 am to 8 am) shift?

Hybrid or Electric Top and Side Handlers: Like hybrid RTGs, hybrid top or side handlers are likely to be operationally feasible as they typically require no changes to existing operating methodologies nor changes to infrastructure; however, there are no US distributors of these models.

Hybrid RTGs are operationally feasible.

Electric RTGs: Electric RTGs are operationally feasible at US East Coast and Asia terminals, but have yet to be demonstrated at West Coast terminals under the jurisdiction of International Longshore and Warehouse Union (ILWU) labor. In an ILWU operating

[7] San Pedro Bay Ports Clean Air Action Plan, 2018 Feasibility Assessment for Cargo-Handling Equipment, August 2019.
[8] Port of Long Beach, Charging Ahead: The Port Community Electric Vehicle Blueprint, May 2019.

environment, there is a unique rule requiring a separation of gate (drayage trucks) and vessel traffic (yard tractors) that does not exist at any facility currently operating with electric RTGs. As a result, RTGs are typically used only for delivering import containers to drayage trucks. At other times, these same stacks will be served by top handlers which fill in the stacks with containers from the vessel. These means that unlike any existing electric RTG facility, top handlers must be able to work adjacent to RTG electrification infrastructure (cable reel trenches or busbars). This causes a significant risk of damage to electrification infrastructure, especially panzer belts[9], and its operational feasibility has yet to be demonstrated. SSA plans to demonstrate electric RTGs at its Pier J Terminal in Long Beach.

Affordability:

Electric Yard Tractors: Zero-emission electric yard tractors may be affordable when co-funded by incentive programs. The affordability of electric charging infrastructure depends on site conditions.

Hybrid or Electric Top and Side Handlers: Little data are available to assess the affordability of hybrid or electric models as no US-based suppliers are currently offering these models at a revenue service level. Current electric top-handler models included in demonstration projects do not have the ability to regenerate energy when braking or lowering containers, which will have a negative impact on their overall operating costs.

Hybrid RTGs: Hybrid RTGs are affordable, particularly when purchased new which avoids the significant cost to repower existing machines. Operating costs for hybrid versus traditional RTGs are approximately cost-neutral compared to traditional machines and may improve operating costs slightly[10].

Electric RTGs: Grid-connected infrastructure costs are exacerbated by the small fleet sizes at each terminal, which are likely to result in very high fixed infrastructure costs.

The following table summarizes the information above for <u>equipment</u> only.

CHE	**Commercial Availability**	**Operational Feasibility**	**Affordability**
Battery Electric yard tractors			
Marine terminals	Unknown	Unknown	Unknown
Off-dock	Yes	Yes	Yes

[9] A panzerbelt is a cable protection system made of a semi-flexible rubber belt with steel reinforcement which lies over a channel cast in the wharf.
[10] Seaport Air Quality 2020 and Beyond Plan, Appendix F, Figure F-14.

CHE	Commercial Availability	Operational Feasibility	Affordability
Battery Electric Top Picks	No	Unknown	Unknown
Side Picks			
Hybrids	Yes, but not in the U.S.		
Battery Electric	No	Unknown	Unknown
RTG Cranes			
(New) Hybrids	Yes	Yes	Yes
Electric	Yes	Unknown	Unknown

CONCLUSION

Port staff determined that the primary challenges of zero-emissions CHE relate to commercial availability, operational feasibility and affordability. Other issues relate to lack of battery-electric charging standards, operating duration between charges, conformity to existing operating needs, electrical infrastructure cost, and the relatively low volume of CHE manufactured.

Consequently, it is not currently feasible to replace all CHE at the Port with zero-emissions equipment or to predict when all CHE will be zero-emissions. The following summarizes the Port's near-term feasible CHE goal from the 2020 and Beyond Plan[11] as well as two additional new near-term goals.

[11] Port of Oakland, Seaport Air Quality 2020 and Beyond Plan, June 2019 Appendix F, Figure F-12.

CHE	Existing Zero Emission Goal[12]	Comments
Yard tractors - on dock	44 ZE by 2025 (20% of total)	Five ZE yard tractors will be demonstrated at SSA's Matson Terminal in 2020/2021. This and other grant funded demonstrations will help determine operational feasibility including acceptability by ILWU labor.
CHE	**New Zero Emission/Near Zero Emission Goals**	**Comments**
Yard tractors – off dock	All new yard tractors shall be zero emissions	Equipment is commercially available, and is expected to be operationally feasible, but tenants will need to apply for (and receive) incentive funding. CARB plans to launch its Clean Off-Road Equipment Voucher Incentive Project, and BAAQMD its Goods Movement Program by early 2020.
RTG cranes	All new RTG cranes shall be hybrid (or all electric).	Hybrid technology is feasible and cost effective for new RTG cranes.

Port staff will monitor CARB's and BAAQMD's incentive programs. Assuming viable zero emissions funding options exist, Port staff will recommend that the Board adopt these two new CHE goals as part of the Port's Near-Term Action Plan during the annual update of the 2020 and Beyond Plan in June 2020. In summary, 25% of the CHE operating at the Seaport will have a zero emission or near zero emission goal.

The Port's Zero Emissions CHE Feasibility Study is available on the Port's web site: https://www.portofoakland.com/community/environmental-stewardship/maritime-air-quality-improvement-plan/.

[12] CHE goal approved by the Board on June 13, 2019.