

GHG and Criteria Pollutant Emission Reduction Estimates

1.0 GHG Reduction Estimate Method

Emission reductions are estimated based on:

- Baseline emissions by equipment type from the Port of Oakland’s most recent (2020) emissions inventory.
- Estimated rates of equipment conversion by type, based on tenant implementation plans.
- Electricity generation emissions for electrified equipment, based on Port and State of California existing electricity mix and goals for achieving zero-carbon electricity.

2.0 Models/Tools Used

Emissions reductions are estimated in a spreadsheet using data and assumptions from various sources as documented below.

3.0 Measure Implementation Assumptions

The grid upgrades are assumed to support electrification of four types of cargo-handling equipment (CHE): cranes, forklifts, other container handling, and yard trucks.

To estimate the timing and rates of electrification of this equipment, information was used from tenant implementation plans for zero-emissions or near-zero emissions technology. Port of Oakland ordinance 4691 required all tenants to prepare and submit these plans by the end of 2023. The Port also provided a summary of these plans. For 19 types of equipment, the plans specify the number of equipment pieces, characteristics such as engine model year, fuel type, anticipated conversion technology (e.g., battery-electric, hydrogen, battery diesel), and year(s) of expected conversion. Plans were not always complete and in some cases the anticipated technology was characterized as “evaluating”. Therefore, the following approach was taken to estimating phase-in schedules:

- Classify the 19 equipment types in the implementation plans into four equipment categories consistent with the Port of Oakland’s 2020 emissions inventory.
- Identify the approximate earliest and latest “planned conversion year” for each equipment type across the tenant plans.
- Assign a linear ramp-up between these two years.
- While some tenant plans specify hydrogen fuel cell technology (mainly for top handlers) or that they are “evaluating” the best technology option, all equipment is ultimately assumed to be converted to zero-emissions.

The implementation phase-in assumptions are shown in Table 1.

Table 1 Implementation Phase-In for Battery Electric Cargo Handling Equipment

Equipment Type	Total Units	Start Year	100% Conversion Year
Crane	172	2026	2035
Forklift	147	2025	2032
Other handling	241	2026	2035
Truck	14	2024	2035

In addition to equipment implementation, it is assumed that the electrical system upgrades to be funded by this grant would be partially activated in 2028 (30 percent) and fully activated starting in 2029. Emission reductions related to the grant funds are therefore only reported for years in 2029 and beyond.

4.0 GHG Reduction Estimate Assumptions

GHG emission reductions were estimated using a “top-down” approach based on total emissions by equipment type as reported in the Port’s 2020 inventory (Port of Oakland, 2021). This was viewed as a more efficient method than conducting a “bottom-up” estimate considering factors such as equipment activity levels, horsepower, engine model year, emission rates, etc. for every tenant of the port and equipment type. That approach would have required substantial collection and analysis of source data (these types of data served as a basis for the Port’s inventory, but the data were not readily available to support the preparation of this grant application).

In addition to the implementation assumptions shown above, the key assumptions to develop the GHG reduction estimates include:

- Baseline future year emissions continue at the same level as base year (2020) emissions, i.e., no changes in activity levels or equipment efficiency.
- All of the electrified equipment is displacing diesel engines. While this may not always be the case, it is assumed that GHG emissions for equipment powered by other types of fuel would be similar. Displaced diesel fuel is back-calculated from CO₂ emissions from the port’s inventory, using a carbon content of 0.01019 metric tons of CO₂ per gallon of diesel fuel.
- Gallons of diesel are converted to megawatt-hours of equivalent energy using a conversion of 0.0374 MWh/gallon diesel (consistent with energy conversions of 3.6 MJ/kWh and 134.47 MJ/DGE – see San Pedro Bay Clean Air Action Plan (2022)).
- Electricity energy consumed is calculated as the energy in the displaced diesel fuel divided by the energy efficiency ratio (EER) of each type of equipment. The EERs for cranes, forklifts, and other CHE are taken from the California Air Resources Board (CARB) Low-Carbon Fuel Standard regulation (CARB, 2020) and are: cranes and container handling as 2.7; forklifts as 3.8. EERs for yard trucks are taken from CARB (2018) as 5.3, the low end of the range shown (5.3 to 7.0).
- The Port of Oakland is its own utility. The Port currently uses over 65 percent renewable sources and has a goal to use 80 percent renewable power sources for its electrical power in the next several years (source: email correspondence with Tim Leong, Port of Oakland, March 2024).

- The Port's Power Content Label identifies that sources other than specific renewables listed are "unspecified sources of power" purchased through the open market. It is assumed that the average grid emissions for California was applied to this share of power. The U.S. Environmental Protection Agency eGRID identifies the average statewide emissions as 897 lb. CO₂e/MWh or 0.407 metric tons CO₂e/MWh in 2022. It was assumed that this emissions rate decreases at a linear rate to zero in 2045, when the State of California has committed to achieving carbon neutrality in its energy supply (<https://opr.ca.gov/climate/carbon-neutrality.html>).

Table 2 shows these key calculated values in five-year increments. Note that benefits in years beyond 2045 are the same as in 2045 since all phase-in cycles are complete and electricity is assumed to be 100 percent renewable.

Table 2 Energy and Emissions Calculated Values

	2025	2030	2035	2040	2045
Displaced diesel fuel (gal)	0	2,373,000	3,971,000	3,971,000	3,971,000
Energy equivalent of displaced diesel fuel (MWh)	0	88,600	148,300	148,300	148,300
Electrical energy consumed by electrified equipment (MWh)	0	23,900	42,200	42,200	42,200
Share of Port-supplied electricity from renewables	65%	70%	75%	80%	80%
California grid emissions rate (mt/MWh)	0.354	0.265	0.177	0.018	0.000
Net Port CO ₂ e emissions rate (mt/MWh)	0.124	0.080	0.044	0.018	0.000

5.0 Reference Case Scenario

The reference case is the baseline emissions for CHE at the Port of Oakland, using 2020 as the base year with the most recent data. Table 3 shows base year emissions from the Port's inventory by equipment type, and for the three types of emissions documented in this application. All values are shown in short tons. Note that short tons of CO₂e were converted to metric tons for the purposes of reporting emission reductions. Reductions of PM_{2.5} and NO_x as shown in the main body of the report are calculated using the same methodology as for CO₂, except that emissions of PM_{2.5} and NO_x are not included. These emissions would be widely dispersed throughout the state, depending upon where the power supplied is being generated, rather than concentrated in the area of the Port of Oakland.

Table 3 Port of Oakland 2020 Emissions (tons)

Equipment Type	CO ₂ e	PM _{2.5}	NO _x
Crane	21,616	1.30	124.03
Forklift	946	0.07	6.46
Other handling	1,404	0.11	6.34
Truck	20,540	1.05	59.04
Subtotal, CHE	44,506	2.53	195.87

6.0 Measure-Specific Activity Data

As noted above, emission reductions are estimated based on the Port's overall inventory and electricity conversion rates rather than a build-up of equipment activity estimates.

7.0 GHG Emissions Reduced

Table 4 shows the total GHG emissions reduced and the components of the emissions changes including displaced fossil fuel emissions and added electricity generation emissions.

Table 4 Port of Oakland 2020 Emissions (metric tons CO₂e)

	2025 – 2030	2025 - 2050
Displaced fossil fuel emissions	49,600	832,200
Electricity generation emissions	4,100	21,500
Net emissions reduced	45,500	810,700

8.0 References

- California Air Resources Board (2018). Battery Electric Truck and Bus Energy Efficiency Compared to Conventional Diesel Vehicles.¹
- California Air Resources Board (2020). Unofficial electronic version of the Low Carbon Fuel Standard Regulation, July 1, 2020.²
- Port of Long Beach and Port of Los Angeles (2022). San Pedro Bay Clean Air Action Plan, 2021 Update: Feasibility Assessment for Cargo-Handling Equipment.³
- Port of Oakland (2021). 2020 Seaport Air Emissions Inventory.⁴

¹ <https://ww2.arb.ca.gov/sites/default/files/2018-11/180124hdbevefficiency.pdf>

² https://ww2.arb.ca.gov/sites/default/files/2020-07/2020_lcfs_fro_oal-approved_unofficial_06302020.pdf

³ <https://cleanairactionplan.org/2022/08/25/san-pedro-bay-ports-release-final-cargo-handling-equipment-assessment/>

⁴ <https://www.portofoakland.com/files/PDF/Port%20Oakland%202020%20Emissions%20Inventory%20Final%20Report.pdf>