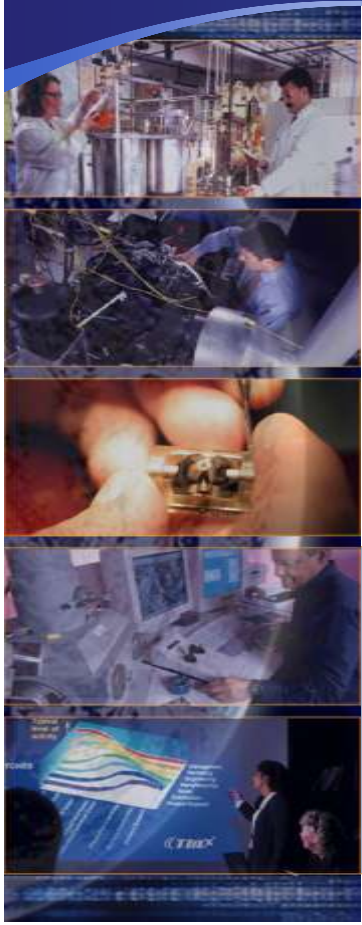

Assessment of Zero-Emissions Cargo Handling Equipment at the San Pedro Bay Ports

Summary of Preliminary Findings

Presented at the
AQMD Clean Fuels Program Advisory Group Meeting
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Reference No.: D0557.05.00

Assessment Objective: To better characterize and understand potential opportunities, costs and benefits of deploying zero-emissions Cargo Handling Equipment (CHE) at the San Pedro Bay Ports

Scope of Work

Tasks 1: Characterize current **fuels, duty cycles, energy usage, costs, and prospects** for zero emissions

Task 2: Characterize actual San Pedro Bay CHE **populations and feasibility** for zero emissions

Tasks 3: Estimate **costs and full fuel-cycle emissions benefits** of most-feasible CHE candidates

Four (non-electric*) CHE types primarily move containers at the Ports:

***Note:** **large wharf cranes perform the very first box move off the ship. However, at the San Pedro Bay Ports these are already grid electrified (“zero emissions”).**

Equipment type	Image	Primary Dock or Rail Yard Application	Currently Deployed Prime Movers / Fuel Types
Yard Hostlers		Move cargo containers within marine terminals and intermodal rail yards	Diesel, Propane, or Natural Gas[a] On-Road Internal Combustion Engine / Conventional Drive[b]
Rubber Tired Grantry Cranes (RTGC) / Rail Mounted Gantry Cranes (RMGC)		Move containers to and from container stacks: make minimal lateral movements	Diesel Off-Road Internal Combustion Engine Gen Set / Electric Drive
Side Picks		Move and stack empty containers	Diesel Off-Road Internal Combustion Engine / Conventional Drive
Top Picks / Reach Stackers		Move, stack and load containers; lift heavy containers within the terminals	Diesel Off-Road Internal Combustion Engine / Conventional Drive

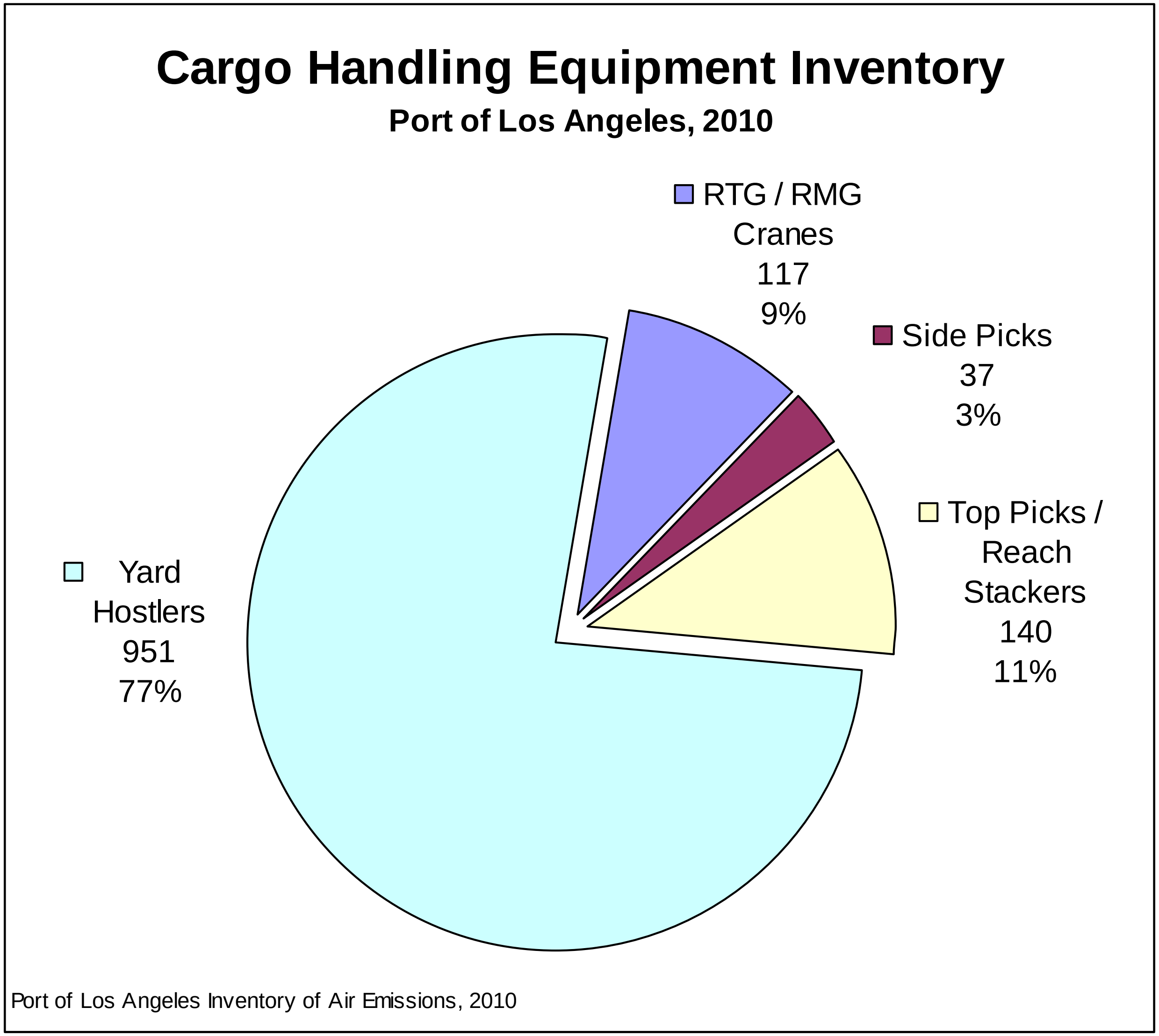
[a]The yard hostler fleet serving both ports is >93% diesel fueled. Relatively small numbers of alternative fuel (natural gas and propane) yard hostlers have been deployed, in essentially pre-commercial capacities.
[b]Proof of concept / prototype yard hostlers with electric drive (plug-in hybrids, battery-only, and fuel cell) are now being demonstrated on very small scales at the San Pedro Bay Ports.

TIAX

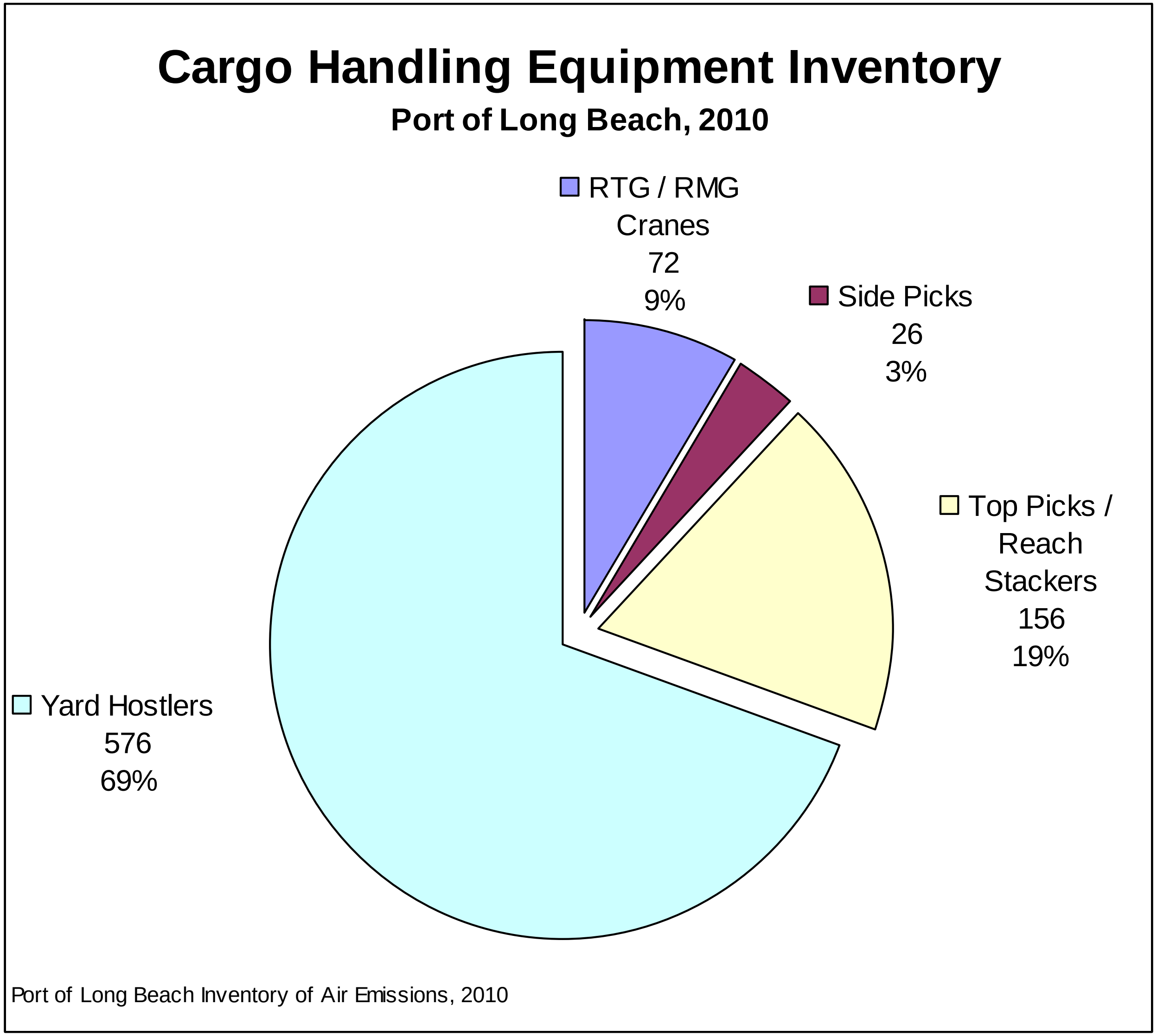
Yard Hostlers and Top Picks are the true “workhorses” of container terminals and intermodal rail yards

- For each Post-Panamax terminal crane that is actively unloading a 6,500 box container ship, approximately **8 yard hostlers** and **3 top picks** are required
- Dockside activity varies significantly by container ship schedule, economy, etc.
- Example at a major POLB terminal with 800,00 annual container throughput:
  - 14 Post-Panamax cranes
  - 23 top picks / side picks
  - 110 yard hostlers
- These “formulas” focus on full throughput capacity, and include <u>backups / redundancy</u>

At POLA, about 3 out of 4 container-moving CHE are Yard Hostlers



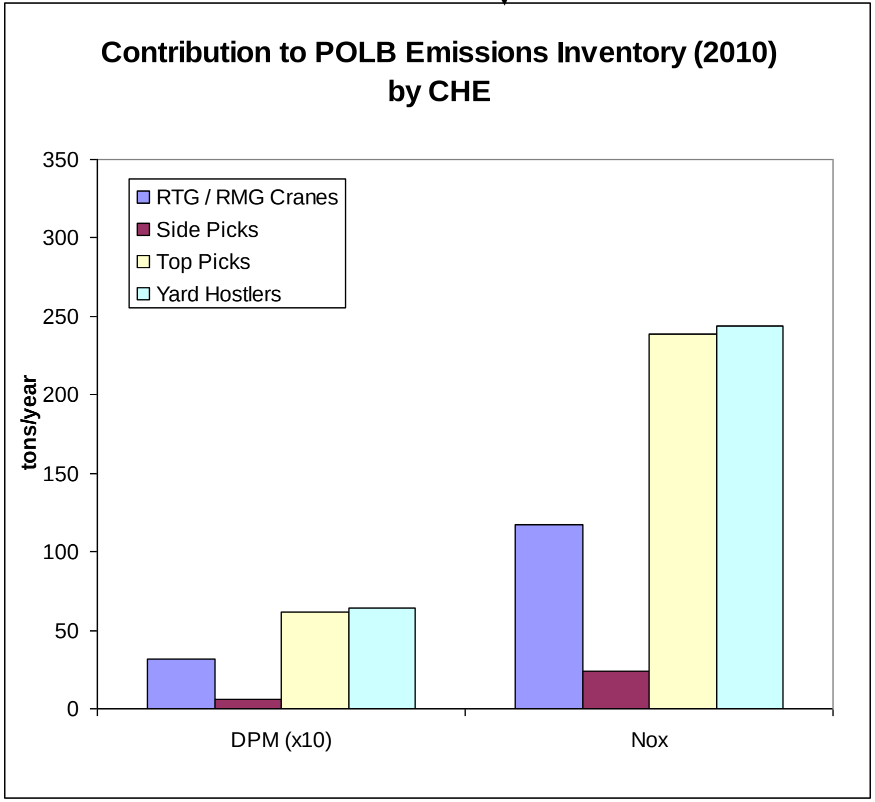
POLB: roughly the same % CHE breakout, but fewer in numbers

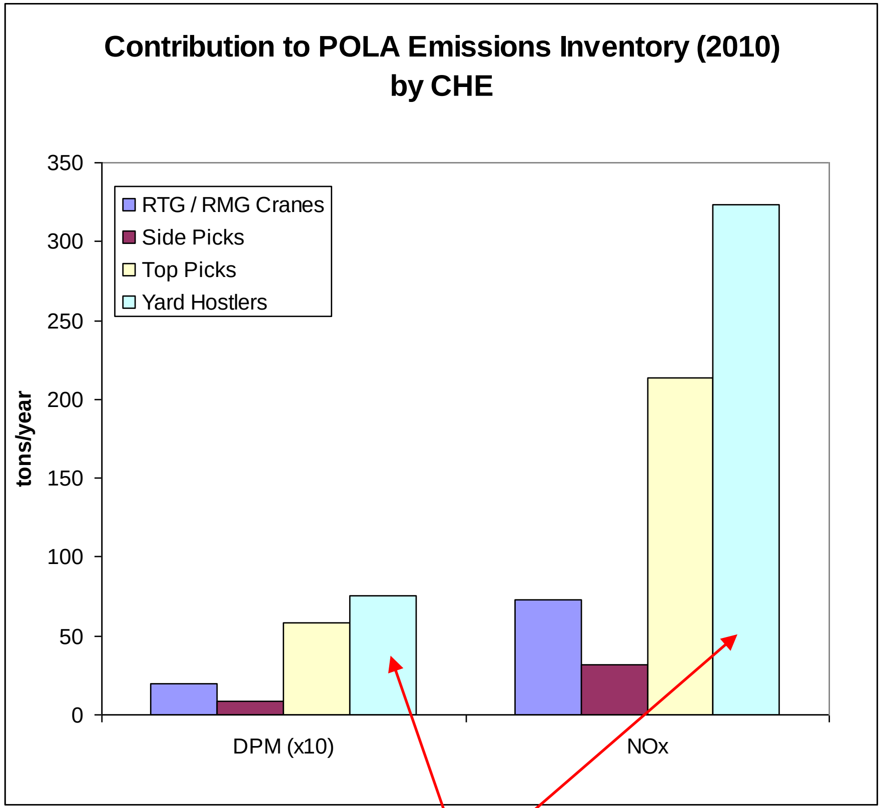


At both ports, Hostlers and Top Picks dominate DPM and NOx emissions from CHE

Port of LA

Port of LB





Yard Hostlers make an especially large contribution to POLA's PM and NOx inventories.

Zero-Emissions CHE Assessment Common Emissions Controls for Mainstream CHE

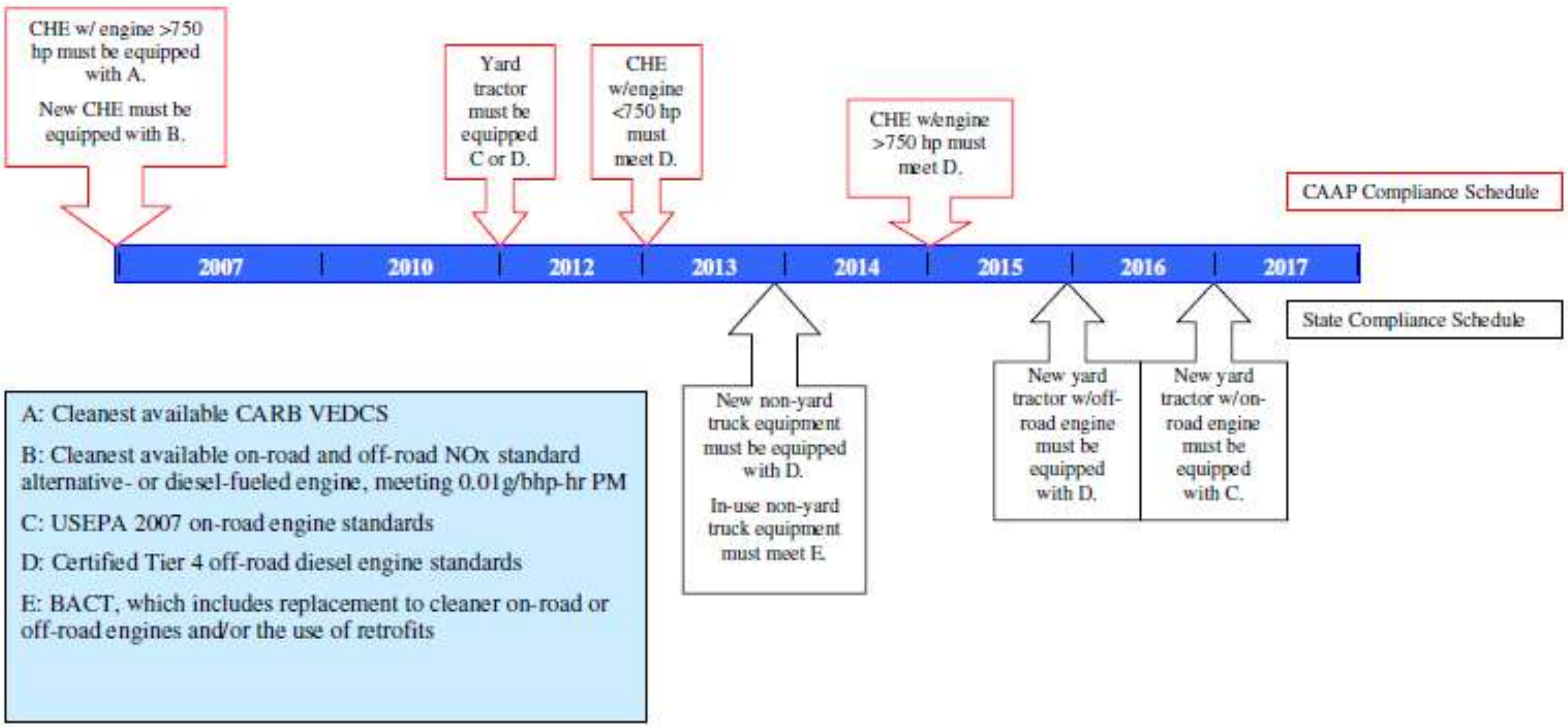
Equipment type	Image	Currently Used Fuel Type(s)	Current Types of Emission Control Technologies / Strategies
Rubber Tired Grantry Cranes (RTGC) / Rail Mounted Gantry Cranes (RMGC)		Ultra Low Sulfur Diesel (ULSD)	Exhaust Aftertreatment (DOC, DPF), Vycon Flywheel
Side Picks		Ultra Low Sulfur Diesel (ULSD)	Exhaust Aftertreatment (DOC, DPF)
Top Picks / Reach Stackers		Ultra Low Sulfur Diesel (ULSD)	Exhaust Aftertreatment (DOC, DPF)
Yard Hostlers		ULSD / O2 Diesel Alt-fuels (LNG, LPG)	Exhaust Aftertreatment, On-Road Certified Engines (Diesel, Alternative Fuels), Prototype Hybrid Electric

Source: San Pedro Bay Ports Clean Air Action Plan and 2010 Emissions Inventories for both ports

Zero-Emissions CHE Assessment Drivers for Lower-Emitting CHE

The Ports' tenants are required to deploy progressively lower-emitting CHE . . .

San Pedro Bay Ports Clean Air Action Plan



But, ZERO-EMISSIONS CHE are needed, and strongly sought by AQMD

Yard Hostlers: best focal point for zero emissions CHE in near term?

- Ubiquitous at the Ports!
  - ~1,600 serving both ports
  - Operated by all terminals and intermodal rail yards (ICTF, future SCIG)
  - Major impact on emissions inventory
- Useage patterns: operated off-road only, for relatively short distances within small confined terminal yards and rail yards
- Duty cycle
  - Lateral movement of containers only
  - No lifting (power takeoff) that requires high-energy-density fuel
- Much synergy with drayage truck RDD&D programs (BEVs, FCVs, HEVs)
- Motivation and drivers: highly visible and strongly targeted
  - SPBP Clean Air Action Plan and Zero-Emissions Container Movement initiative
  - South Coast AQMP, “Black Box” provision, and port “Backstop” plan
  - CARB’s general push towards ZEVs
- Original equipment manufacturers clearly see a near-term market!
- Leasing programs are emerging to cut end user costs

Electric-Drive Hostlers are being demonstrated now at the Ports . . . commercialization pathways include plug-in power and fuel cells

- U.S. Hybrid's Hybrid Yard Tractor (Long Beach Container Terminal)
- Balqon's **Battery-Electric** E20 Nautilus (Cal Cartage)
- Capacity's **Plug-In** Hybrid Electric Terminal Tractor (PHETT) (Hanjin / TTI)
- Vision Motor Corp's H2 Fuel Cell / **Plug In** Hybrid Zero Emissions Terminal Tractor (ZETT) (Cal Cartage)

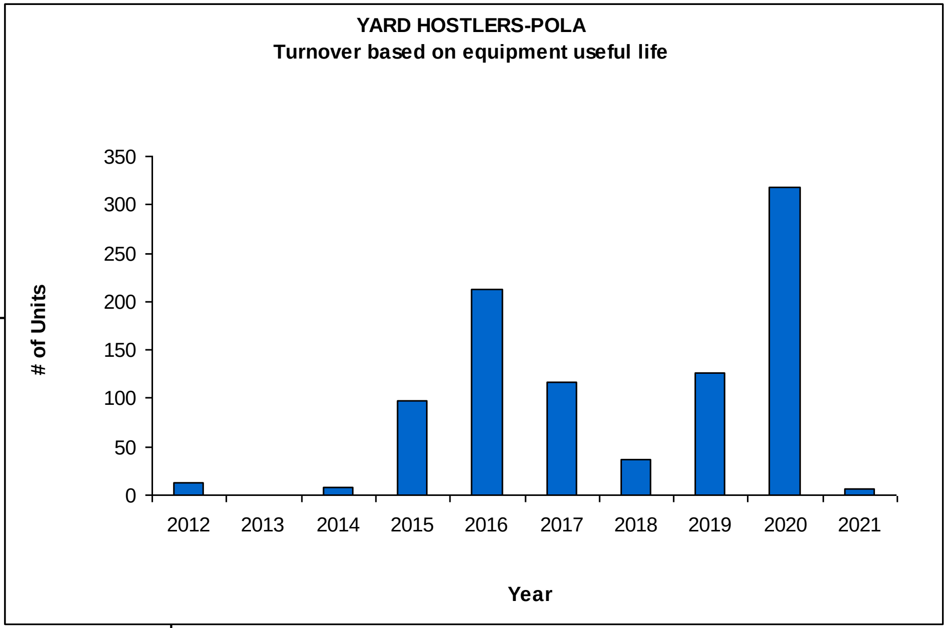
U.S. Hybrid's yard hostler testing (LBCT)

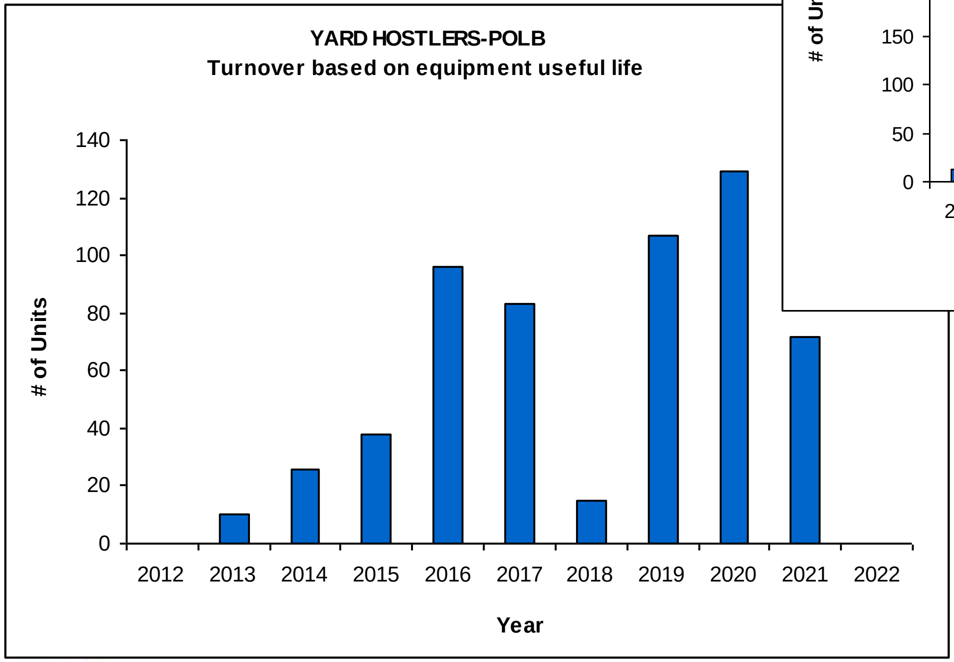
Balqon's All-Electric Yard Tractor demo (Cal Cartage)

Zero-Emissions CHE Assessment Hostler Populations by Useful Life

There are about ***1600 yard hostlers*** *serving both ports (~940 at POLA). Over the next decade, they will gradually need replacement based on their useful lives. But, so far there are no hard drivers for early retirement / replacement with BEVs.*

Port of LA

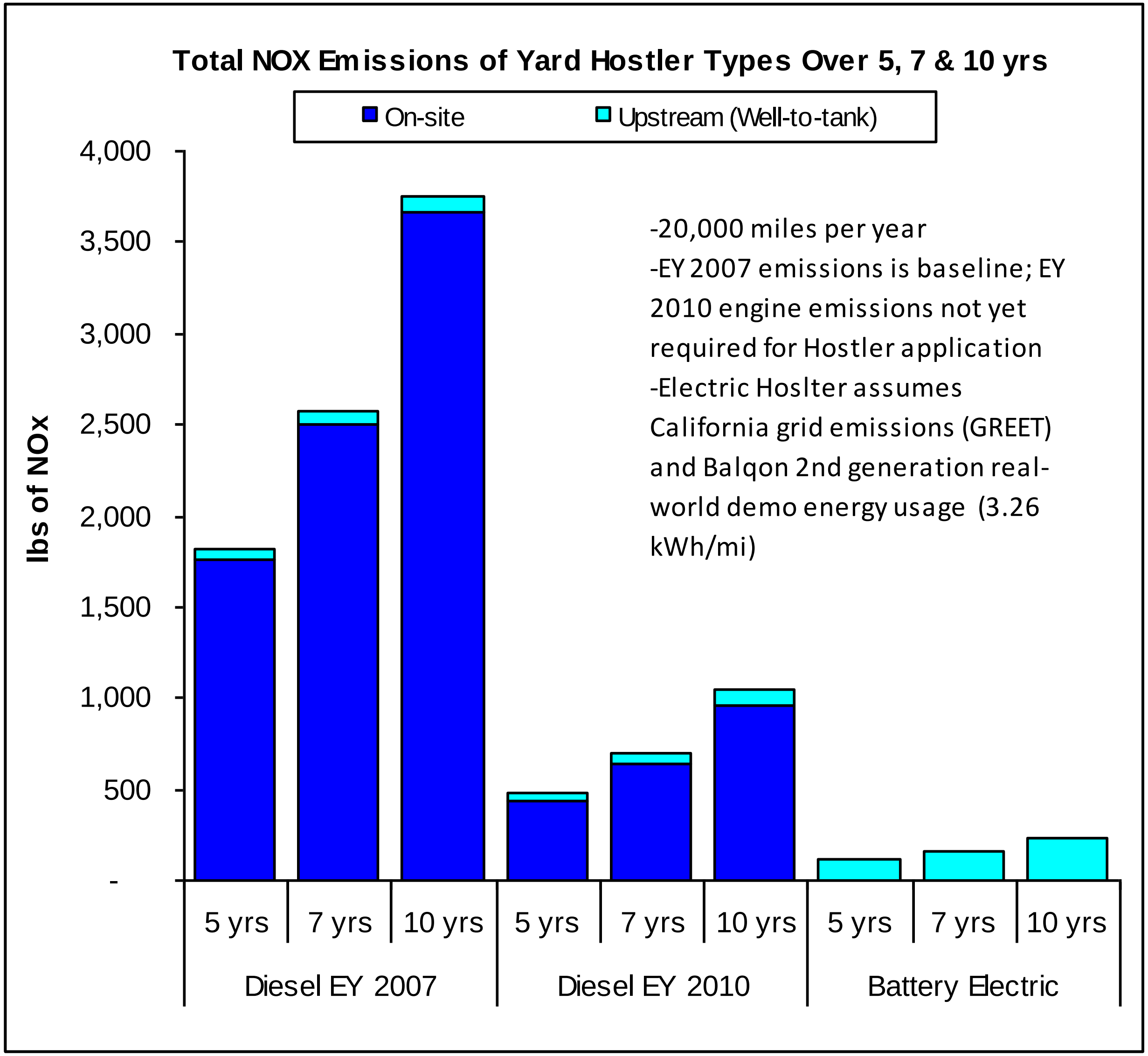




Port of LB

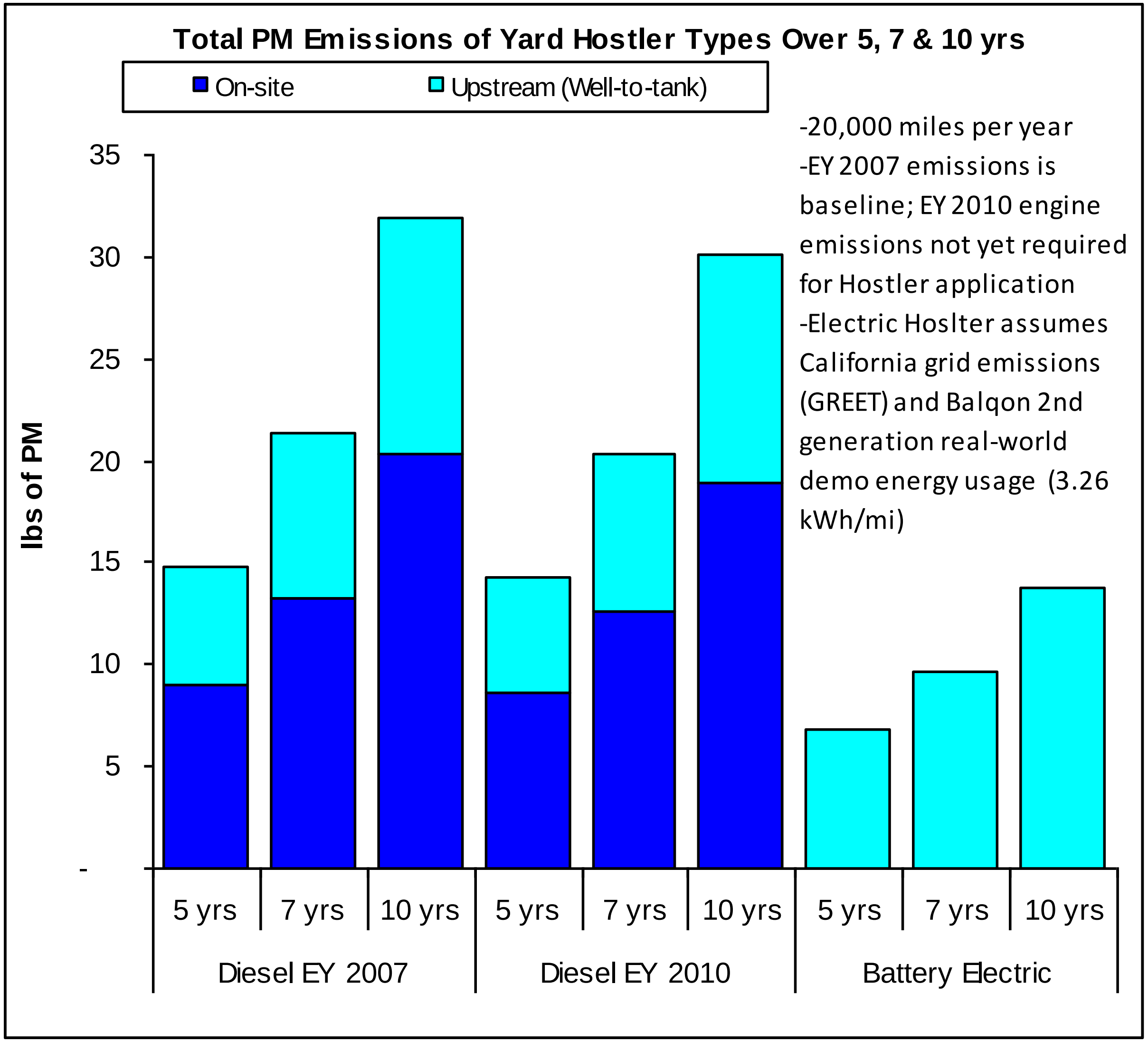
Zero-Emissions CHE Assessment Battery-Electric Hostler Estimated Emissions Benefits (NOx)

*The **full fuel cycle emissions** profiles for battery-electric yard hostlers offer very compelling **NOx** reductions compared to baseline diesel hostlers.*



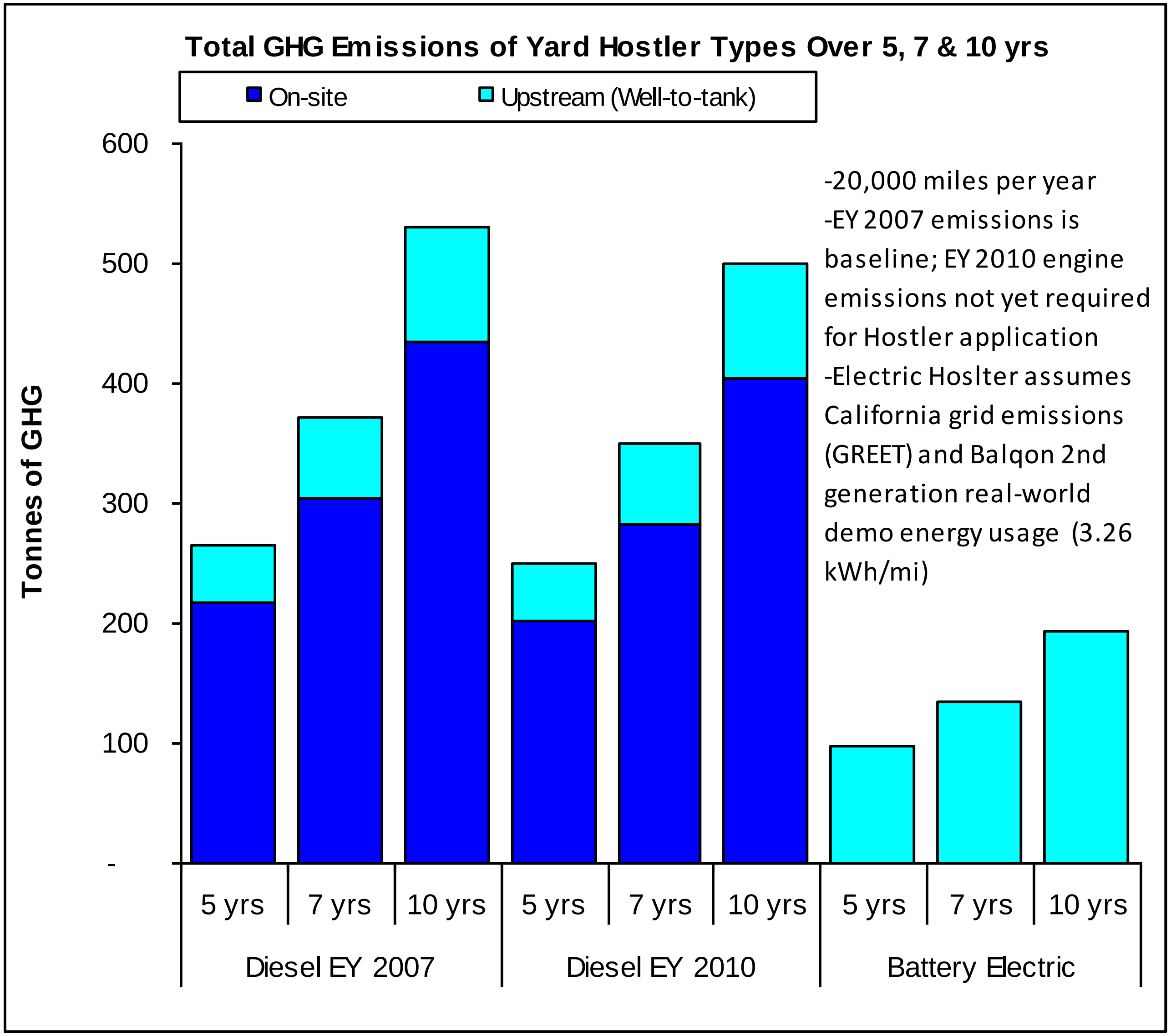
Zero-Emissions CHE Assessment Battery-Electric Hostler Estimated Emissions Benefits (PM)

*The **full fuel cycle emissions** profiles for battery-electric yard hostlers offer very compelling **PM** reductions compared to baseline diesel hostlers.*

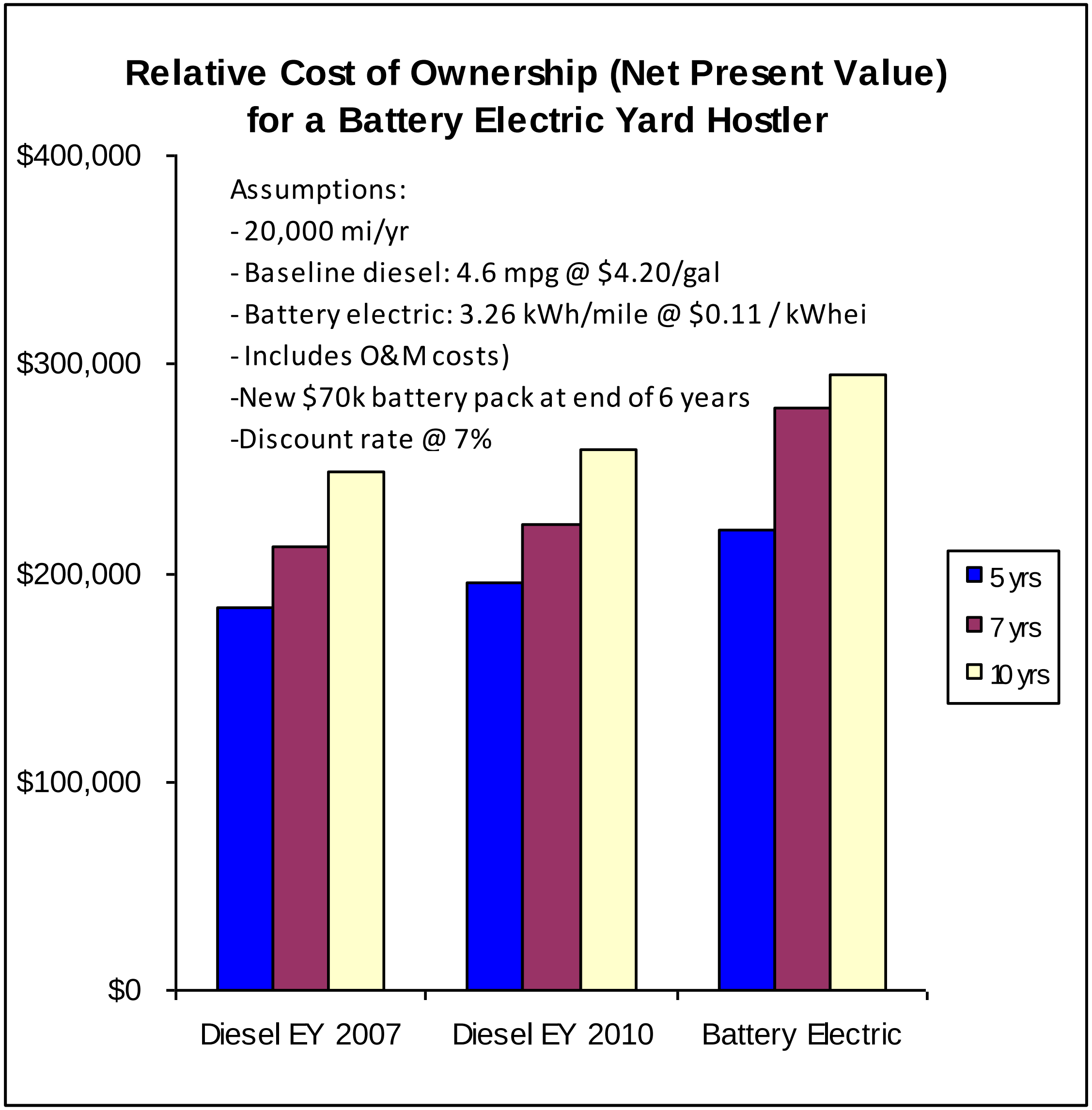


Zero-Emissions CHE Assessment Battery-Electric Hostler Estimated Emissions Benefits (GHG)

*The **full fuel cycle emissions** profiles for battery-electric yard hostlers offer very compelling **GHG** reductions compared to baseline diesel hostlers.*



The cost of owning emerging ZEV technology is heavily impacted by high capital costs.



Zero-Emissions CHE Assessment Estimated Costs *Yard Hostlers (cont'd)*

The estimated cost of ownership for battery-electric yard hostlers (vs.baseline diesel) presents challenges. ***Incentives*** *will initially be needed to offset higher costs and accelerate payback.* ***Leasing*** *programs will greatly lower costs.*

Cost Categories	Baseline: New Diesel w/ 2007 Emissions	Balqon Nautilus XR E20 Battery Electric	Notes
Capital Cost			
Purchase Price	$ 100,000	$ 195,000	Estimated based on current pricing for single truck orders. Manufactuer Suggested Retail Price may be significantly different.
Fuel Cost			
Fuel Cost per Mile	$ 0.91	$ 0.36	Baseline Diesel: $4.20 / gallon, 4.64 mpg from EMFAC; Battery Electric: avg $0.11/kwhe, 3.26 kWh/mile (from Balqon demo 2nd generation)
Annual Fuel Cost	$ 18,110	$ 7,172	Assumes on 20,000 annual miles
Maintenance Costs			
Cost of Maintenance per Mile	$0.198	$0.110	Electric vehicle assumes 50% reduction in break wear and oil/lube costs, no aftertreatment maintenance
Annual Maintenance Cost	$ 3,954	$2,200	Based on 20,000 annual miles
Replacement Battery at Year 6	$ -	$70,000	Assumes replacement after end of 5 year warranty
Total Costs			
Five Year Cost (Net Present Value)	$183,925	$220,670	Assumes 7% discount rate
Seven Year Cost (Net Present Value)	$212,367	$279,395	
Ten Year Cost (Net Present Value)	$248,427	$294,712	

Top picks: dockside workhorses; conducive for BEV logistics but (so far) very challenging for electrification

Manufacturer's Name and Model:	Taylor THDC-955 "Big Red"
Fuel Type:	Diesel
Fuel / Hydraulic Tank Capacity (gals):	240 / 200
Rated Lift Capacity / 101-in load center (lbs):	80,000 @ 2-high stacking
Rated Lift Capacity / 236-in wheelbase (lbs):	75,000 @ 3-, 4-, and 5-high stacking
Maximum Lift (ft):	42
Typical Engine (2011 model):	Tier III certified Cummins QSM11-335 turbocharged, charge-air-cooled diesel
Brake Horsepower / Peak Torque (ft-lbs):	365 @ 1,800 rpm / 1235 @ 1400 rpm

- Duty cycle: short distance travel . . . but must repeatedly lift up to 75k lbs. 10 to 40 ft.
- Diesel baseline: two shifts, 10 minute refuel time(s) as needed
- BEV version: must provide range and/or fast charge function to achieve at least one equivalent shift

RTGCs: diesel-fueled gen sets . . . theoretically ripe for grid power

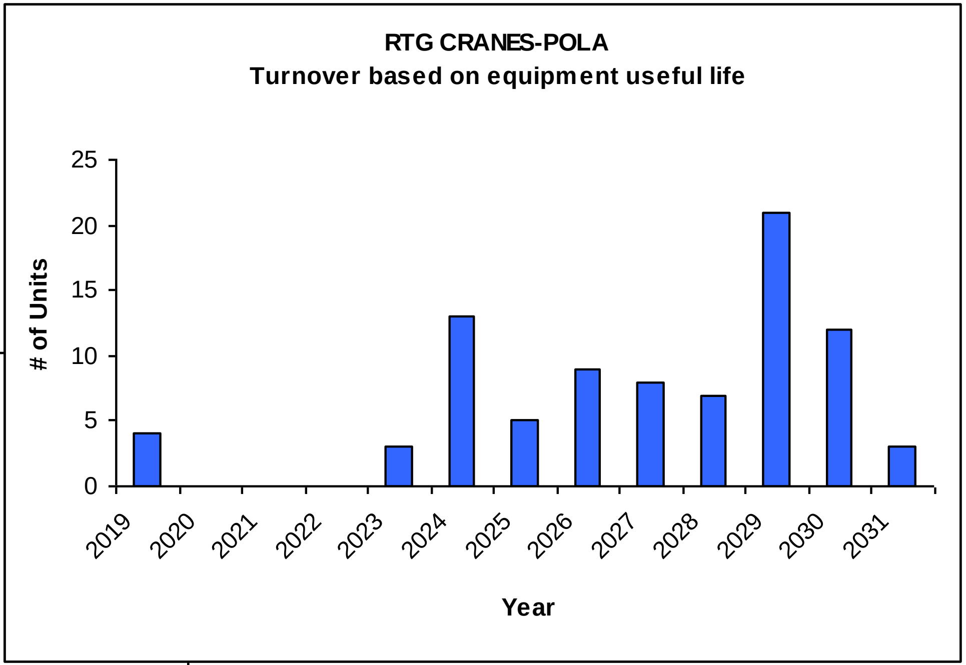
- RTGCs are frequently focused upon as targets for grid electrification
- San Pedro Bay Ports have ~ 127 working diesel-electrics
- Emerging commercial options: retrofits and new e-RTGCs
- . . but locally and worldwide, deployments are in their infancy
- South Coast: ICTF and SCIG to be test cases for e-RTGCs?
- Cost effectiveness an issue

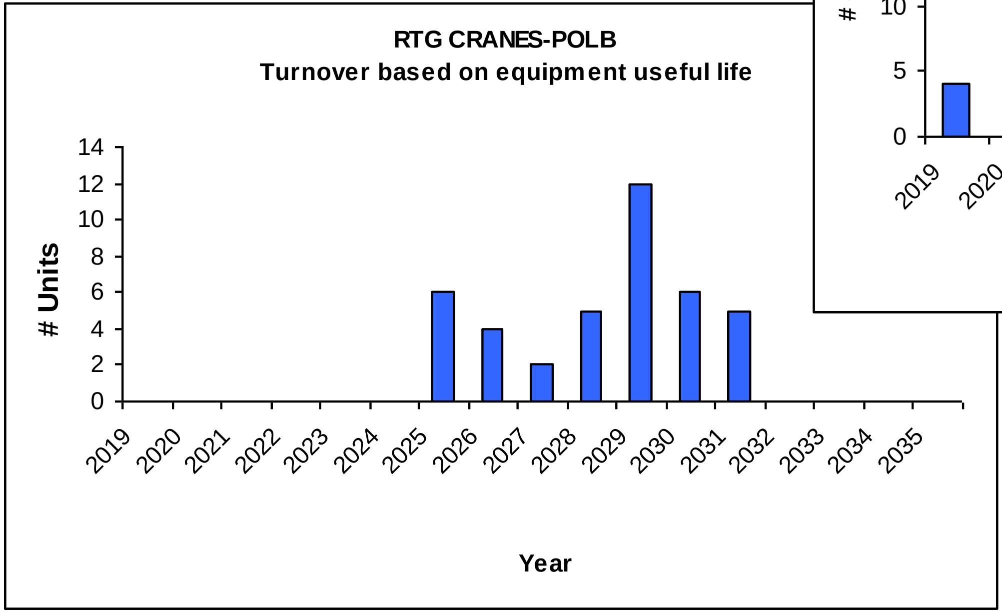
Diesel-fueled generator side needs to be replaced with grid power module

Zero-Emissions CHE Assessment RTGC Populations by Useful Life

*There are about **127 RTGCs** actively serving both ports. Over the next 15 years, they will gradually need replacement based on their useful lives. There are no hard drivers for early retirement / replacement to all-electric versions.*

Port of LA





Port of LB

Approximately 60 grid-electric RTGCs have been tentatively planned for expansion of near-dock rail operations over the next 5 to 10 years

Near-Dock Facility	Type of Project	Phase-In Period for Full Operation	# of Grid-Electric Gantry Cranes (at Full Capacity)
UPRR ICTF	Expansion / Modernization	2015 to 2017 (?)	39*
BNSF SCIG	New Facility	2016 to 2023	20**
Total Number Expected for Phase In (10 Years)			**59**

*Source: Union Pacific Railroad website ("ICTF Modernization")

**Source: Port of Los Angeles (SCIG EIR)

However, pure-electric (zero-emissions) RTGCs are ***not yet required*** at either facility

Zero-Emissions CHE Assessment Findings and Conclusions (Preliminary / Partial)

- Zero-emissions CHE at the two ports are a top priority for AQMD and other stakeholders
- Grid-electrified **yard hostlers** and **RTGCs** are feasible and underway, although many challenges remain (especially higher capital costs)
- The best focal point appears to be yard hostlers
- "W2W" emissions reductions (NOx, PM, ROG, GHG) from one B-E hostler
  - Significant and compelling
  - Fleet wide deployments will pay huge air quality dividends
- High incremental costs are a barrier, but not a show stopper
  - Over 5 years (NPV) it will cost ~26% more to purchase and operate a battery-electric hostler
  - Amortizing a battery pack replacement (7 year case) makes it ~39% higher
  - This recedes back to +26% after 10 years.
- At least one battery-electric yard hostler manufacturer (Balqon) is aggressively pursuing **leasing programs** that will significantly lower end user costs
- Incentives are needed
  - Higher importance on **ZERO tailpipe pollutants** (especially diesel PM)?
  - Monetize **petroleum displacement** and **GHG / air toxic reductions**?

Thank You!

- **Comments**
- **Questions**
- **Discussion**
- **Next Steps?**