HYBRID RTGS

ON THE PATH TO ZERO-EMISSIONS

Krystle McBride, Transportation Planner; Catherine Mukai, Air Quality and Greenhouse Gas Specialist, Port of Oakland; and Diane Heinze, Port of Oakland; California, USA

AECOM

As California seaports near impacted communities strive towards zero-emission operations, owner-operators have significant questions regarding infrastructure, reliability, maintenance, and cost-effectiveness of converting existing diesel fleets to fully electric operations. This article considers the conversion of diesel rubber-tired gantry (RTG) cranes at the Port of Oakland where a marine terminal operator has opted to convert all its RTG cranes to hybrid RTGs.

For some background on RTG hybridizing, the tenant handles 60% of the container volume at the Port of Oakland and uses 13 RTGs to load import containers onto drayage trucks. Average annual activity was 2,172 hours per RTG in 2018. In June 2018, the tenant applied for and was awarded a $5 million Carl Moyer Program grant to repower the RTGs from the Bay Area Air Quality Management District, covering 85% of total project costs; they are now in the process of scrapping existing 947-1063 hp diesel engines to a hybrid battery/generator set with 142 hp diesel engines. As of late September 2019, six hybrid RTGs are operational, and all but two hybrid retrofits have been delivered. The old diesel engines had very high hp and consumed 10-12 gallons of fuel/hour while the hybrid RTG uses about 1.2 gallons/hour. The genset operates 45% of the actual RTG run time, and regenerative power captured while lowering containers provides 20% of the battery power. Annual emission reductions are 0.1 tons/year DPM, 36 tons/year NOx, and 1,200 metric tons/year CO2.

This immediate step affords significant emission reductions. We examine the pros and cons of diesel, hybrid and electric RTG cranes, comparing both annualized operating (OpEx) and capital (CapEx) costs, and overall emission reductions (for DPM and CO2) that other operators may achieve by following this example and converting to hybrid RTGs.

While we examine the Oakland case study, it should be noted that there is a great deal of variability in cost categories depending on:

- What are the ages and horsepower of existing RTGs? The older and larger the engine on existing cranes, the more emissions can be reduced by either hybridizing or electrifying, and the more fuel and maintenance savings can be recouped.
- How many hours do RTGs operate per year? Highly utilized RTG fleets will benefit more from full electrification as they can take better advantage of OpEx savings, while hybrids may be more suited to lower utilization operations typical at many US West Coast container terminals, to avoid high fixed infrastructure costs in the near-term.
- What is the condition and capacity of existing electrical infrastructure, and how much construction and cost is needed to upgrade to grid-connected electric equipment? How much digging is involved and what is the likelihood of subsurface contamination? Some marine terminals in California may have surplus capacity from recent upgrades such as to allow shore power, while others may see significant infrastructure costs to expand terminal electrical capacity.

We examine four key cost categories: equipment purchase, infrastructure CapEx, maintenance, and energy.

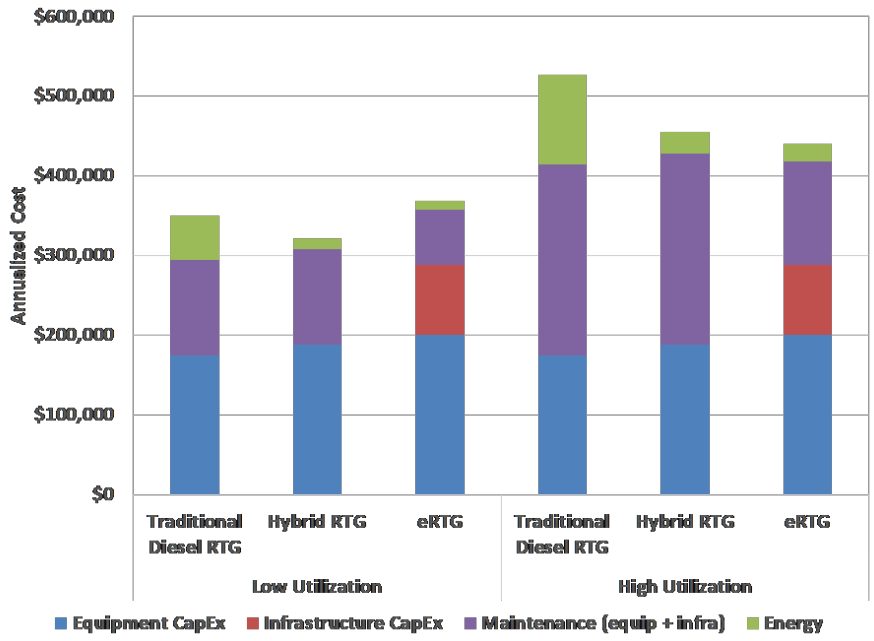

Figure 1: Annualized Cost Comparison per RTG. Fixed CapEx annualized at 6% interest.

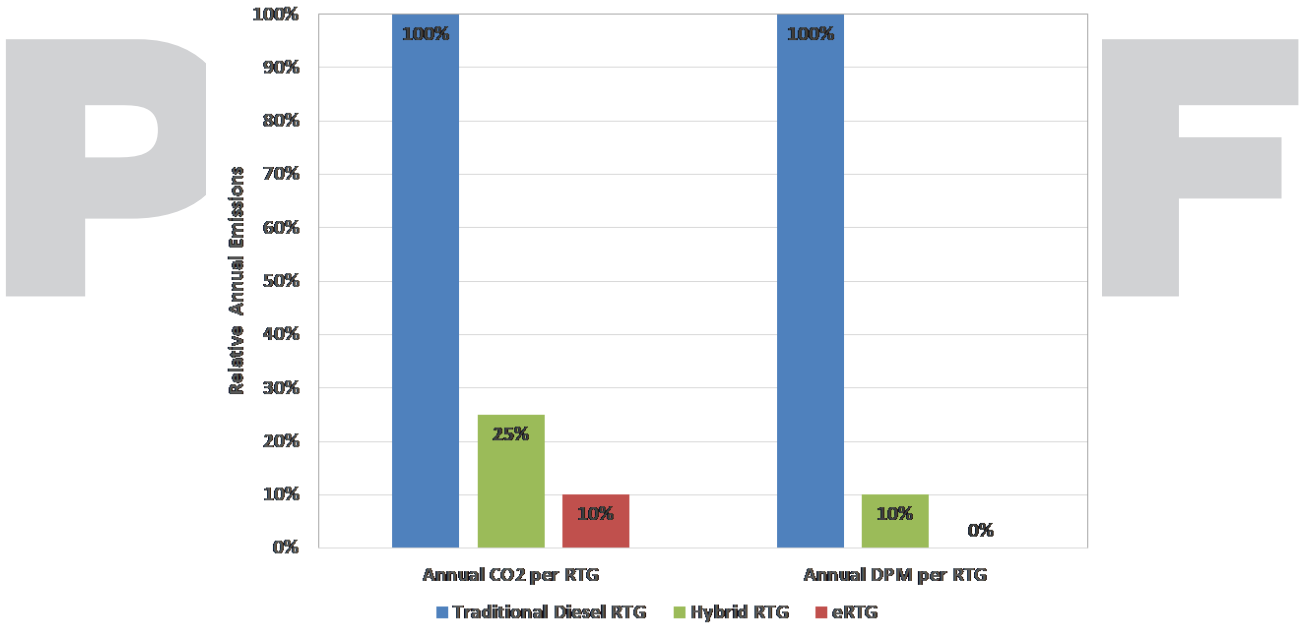

Figure 2: CO2 and DPM reductions per RTG

EQUIPMENT CAPEX

To compare equipment CapEx, we assume traditional diesel RTGs cost $2M each versus $2.15M for hybrids and $2.3M for eRTGs. All are assumed to last 20 years for annualization purposes.

INFRASTRUCTURE CAPEX

No new infrastructure is required for traditional diesel or hybrid RTGs, while we estimated eRTG infrastructure at roughly $10M for a fleet of 10 RTGs. The magnitude of eRTG infrastructure cost is highly variable depending on the condition of the potential site and how RTGs are operated. This cost is based on an estimate of $11M for a project to install 9 eRTGs in San Pedro Bay. This cost may seem high to RTG operators worldwide, but RTG operations on the US West Coast are unique. RTGs are typically used only for delivering import containers to drayage trucks, with top- or side-picks used for export containers and all other moves. Additionally, the same container stacks are typically served by both RTGs and top/side picks at different times, with RTGs moving between rows as needed to serve gate trucks. This means more infrastructure in the form of either cable reels or busbars is needed per RTG than a pure RTG (no pick) operation. This sharing of space between RTGs and picks also brings about significant issues with regards to eRTG infrastructure compatibility with this operating style, as picks may cause damage to eRTG infrastructure such as the panzerbelt.

MAINTENANCE OPEX

We assumed hybrid RTGs do not significantly reduce maintenance costs since they require both batteries and internal combustion engines, while eRTGs

RTG Comparison Case	Traditional vs. Hybrid		Traditional vs. eRTG		Hybrid vs. eRTG	
Annual RTG Utilization: Low or High	eRTG	High	Low	High	Low	High
$ per MT of CO2 eliminated	-$237	-$291	$127	-$295	$1,960	-$317
$ per lb of DPM eliminated	-$1,340	-$3,690	$772	-$3,590	$19,770	-$3,195

Table 1: Cost of CO_2 and DPM Emission Reductions. (Negative = Cost Savings)

will cut equipment maintenance in half. This cost is assumed to be $60/hour of operation for both traditional diesel and hybrid RTGs, and $30/hour for eRTGs. Infrastructure maintenance for eRTGs is estimated at 1% of CapEx annually, or $100,000/yr.

ENERGY OPEX

Traditional diesel RTGs are assumed to burn 8 gal/hr of diesel. This number is highly variable depending on RTG engine age and horsepower; this figure is typical for many RTGs still in operation in California. For example, the 2018 Port of Los Angeles Air Emission Inventory shows that on average RTGs across the port burned about 8.4 gallons of diesel per operating hour, based on their CO2 emissions. Hybrids are assumed to burn 2 gal/hr of operation, while eRTGs are estimated at 40 kWh of electricity per hour. Diesel (tax-free red-dye) is estimated at $3.50/gal and electricity at $0.14/kWh. It should be noted than 2.0 gal/hr for hybrids is quite conservative compared to the tenant's early results, which show hybrid RTGs are burning around 1.2 gal/hr.

Another significant variable is total annual operating hours per RTG. Highly utilized hybrid or electric RTGs will have better cost performance than lightly utilized machines, as they can better take advantage of their lower operating costs. Figure 1 presents cost comparisons for two utilization levels per RTG per year: Low utilization at 2,000 hours vs. high utilization at 4,000 hours. The lower utilization is typical of many US West Coast container terminals, whereas 4,000 hours is more typical of a US East Coast RTG operation where RTGs often handle nearly all loaded containers (not just gate deliveries).

Figure 1 shows that for low utilization operations, hybrid RTGs may have a cost advantage over eRTGs, while eRTGs are superior for high utilization RTG operations. Both hybrids and eRTGs may be more cost-effective than traditional diesel RTGs, depending on fixed infrastructure costs and level of utilization.

Next, we examine emission reductions, and the relative cost-effectiveness of each case. Electricity generation emissions for eRTGs are based on California state averages from the EPA's eGRID database. DPM emissions are assumed to reduce 90% when converting from traditional to hybrids, as significant emission reductions are achieved when installing newer, smaller engines.

Figure 2 shows relative annual CO2 and DPM emissions, respectively, for electric and hybrid RTGs compared to traditional diesel RTGs at 100%.

Figure 2 shows there are substantial emission reductions possible when converting to either hybrid or full electric RTGs. Table 1 shows how these compare in terms of cost per amount of emission reduction.

Table 1 shows that hybrid RTGs reduce overall costs in all cases regardless of utilization level, whereas eRTGs save money compared to traditional RTGs only if they are highly utilized; eRTG cost-effectiveness is also highly sensitive to fixed upfront infrastructure costs that can vary substantially from terminal to terminal. Finally, the last two comparison columns compare the relative cost of emission reductions for the hybrid case vs. the eRTG case (i.e. the cost to move from the hybrid RTG emissions column down to the eRTG column in Figure 2). For typical low RTG utilization US West Coast operation, this incremental emission reduction is as much as $1,960 per metric ton of CO2 or $19,770 per lb of DPM eliminated with eRTGs compared to hybrid, highlighting the potential cost advantages of hybrid RTGs as a near-term solution.

As a result of the Oakland tenant's success in achieving significant emission reductions, the Port of Oakland has identified hybridizing of RTGs as a viable near-term strategy to achieve significant emissions in their Seaport Air Quality 2020 & Beyond Plan, as has the San Pedro Bay Ports in their 2018 Feasibility Assessment for Cargo Handling Equipment. Terminal operators can both save money and begin the process of hybridizing existing RTG immediately, rather than waiting for the results of eRTG pilot projects, studies of how eRTGs might be able to function in the unique US West Coast operating environments, terminal by terminal investigations of electrical infrastructure suitability, and long permitting processes required to install eRTGs. Hybridizing existing RTGs and/or purchasing any new RTGs as hybrids will result in significant reductions in the near-term, with minimal disruption to ongoing operations or without any changes to operational status quo. Hybridizing RTGs will result in healthier workplaces for terminal staff, cleaner air for local communities, and lower climate impacts.

ABOUT THE AUTHORS

Krystle McBride is a transportation planner in AECOM's Oakland marine planning & simulation group. She has worked on dozens of marine and rail planning, simulation, design, and sustainability projects across North America over the course of her career.

Catherine Mukai is an Air Quality and Greenhouse Gas specialist with experience in air permitting and compliance, land use, and CEQA.

Diane Heinze oversees the seaport's environmental work for the Port of Oakland. Together with four staff they ensure the seaport maintains compliance with environmental laws and regulations and obtains entitlements for tenant projects.

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