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MEMORANDUM

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TO: JT Steenkamp, Prologis

FROM: Patrick Couch, GNA

SUBJECT: Comparison of emissions for alternative technologies at Denker

Background

Prologis operates a microgrid at its Denker facility in Los Angeles designed to support charging of heavy-duty electric vehicles. The microgrid includes 8.64MW of EV chargers (24x 360kW chargers), supplied by ~10MW of peak on-site power via 2.76MW of linear generators and 7.2 MW (18MWh) of battery storage. The facility enables the use of heavy-duty electric vehicles (HDEV) that avoid emissions from traditional diesel trucks that would otherwise operate from the facility. However, the site's use of linear generators does entail some direct emissions. This memorandum summarizes the methodology and results used to compare the emissions associated with the Denker facility under a diesel baseline, the constructed HDEV project, and two alternative technology options; 1) the use of near-zero emission natural gas trucks and 2) the use of solid oxide fuel cells (SOFC) in place of the linear generators.

Methodology

Emissions for oxides of nitrogen (NOx), particulate matter (PM2.5 and PM10), and volatile organic compounds (VOC) were characterized for each technology option, with two exceptions. PM emissions data were not available for the linear generator or SOFC technologies. All emissions were characterized on a grams-per-mile basis as this most uniformly compares the work done by the trucks that would operate at the facility. Further, all trucks were assumed to be Class 8 semi-tractors typical of trucks serving the San Pedro Bay Ports and operating in local goods movement.

Data sources and specific methods by technology type

Diesel – emissions data for each pollutant were taken from California Air Resources Board's (CARB) EMFAC emissions model for on-road vehicles. EMFAC is the required emissions model for estimating emissions inventories as part of the State Implementation Plan required under the federal Clean Air Act. The model provides estimates of total emissions (tons per year) for each pollutant and total miles traveled per year by vehicle type. Note that the EMFAC model provides emissions for Reactive Organic Gases (ROG) and it was assumed that ROG and VOC emissions are approximately equal.

For this analysis, the baseline diesel truck emissions and activity reflected the following EMFAC settings:

MODEL SETTING	VALUE
Region	South Coast Air Basin
Calendar Year	2022
Vehicle Category	T7 POLA Class 8
Model Year	2015
Speed	Aggregate

CNG with Near-zero Engine – emissions data for each pollutant were taken from EMFAC. The truck model year is assumed to be 2022 and is intended to reflect an alternative deployment of new vehicles (CNG rather than EV). The following EMFAC settings were utilized:

MODEL SETTING	VALUE
Region	South Coast Air Basin
Calendar Year	2022
Vehicle Category	T7 POLA Class 8
Model Year	2022
Speed	Aggregate

MFC to EV – this scenario reflects direct emissions occurring from natural-gas fueled linear generators (also called a "mechanical fuel cell" or MFC) associated with the generation of electrical energy needed to charge and power a Class 8 HDEV. Test data provided by the generator manufacturer, Mainspring Energy, were used to derive emissions from the generator on a grams-per-kilowatt-hour (g/kWh) basis. Emissions data were averaged over three tests and included two "cores" or power-generating units. Testing was performed under South Coast Air Quality Management District (SCAQMD) test methods 100.1, 2.3, 4.1, and 25.3.

Energy-specific mass emissions from the generators (in g/kWh) were converted to grams per mile of HDEV operation assuming an energy economy of 2.1 kWh/mile. This factor is consistent with energy economies reported for Class 8 trucks operating in the South Coast Air Basin in drayage and local goods movement.

SOFC to EV – this scenario reflects direct emissions occurring from a solid oxide fuel cell associated with the generation of electrical energy needed to charge and power a Class 8 HDEV. Emissions data were based on the Series 10 product fueled with standard pipeline natural gas. Data provided by the generator manufacturer were used to derive emissions from the generator on a grams-per-kilowatt-hour (g/kWh) basis. Testing was performed under SCAQMD test methods 100.1 and 25.3.[1]

Energy-specific mass emissions from the generators (in g/kWh) were converted to grams per mile of HDEV operation assuming an energy economy of 2.1 kWh/mile. This factor is consistent with those reported for Class 8 trucks operating in the South Coast Air Basin in drayage and local goods movement.

Results

Based on the assumptions and data sources described above, the following emissions rates were calculated for each technology type.

PROJECT TYPE	NOX (G/MI)	PM 2.5 (G/MI)	PM 10 (G/MI)	VOCS (G/MI)
Linear Generator with NG	0.06	N/A	N/A	0.06
Solid Oxide Fuel Cell	0.002	N/A	N/A	0.01
Diesel Trucks	1.78	0.03	0.03	0.04
CNG NZE Trucks	0.32	0.003	0.003	0.02

[1] https://www.bloomenergy.com/wp-content/uploads/Series10-V12.pdf

As shown, the linear generator and SOFC technologies offer the lowest NOx emissions rates, providing over 96% NOx reductions relative to the diesel baseline.

As previously noted, PM emissions data were not available for the SOFC and linear generator but are expected to be very low owing to the continuous (not intermittent) fuel oxidation processes that are inherent in these technologies.

VOC emissions for all technologies are very low. Typically, diesel engines emit VOCs predominantly as hydrocarbons. Certification levels for hydrocarbon emissions from diesel engines are often 90% or more below the current State and federal emissions limits. As all technologies produced VOC emissions of the same order of magnitude as the baseline diesel engine, it is evident that the VOC emissions are well below the existing diesel standards.