October 16, 2024

Rajinder Sahota
Deputy Executive Officer, Climate Change and Research
California Air Resources Board
1001 I Street
Sacramento, CA 95814

Re: Comments on the Second Proposed 15-Day Changes to the Low Carbon Fuel Standard (LCFS) Amendments

Dear Ms. Sahota:

We represent a group of distinct businesses and perspectives related to the Low Carbon Fuel Standard (LCFS) and the State's various climate change-related programs. Individually, we each have specific priorities and recommendations for the program, which we may address in separate comment letters. Collectively, however, we agree that the LCFS is a critical program for achieving the State's methane reduction, transportation electrification, and other climate change related goals.

We would like to thank CARB for incorporating additional flexibility in the recent proposed 15-day changes to the LCFS, particularly the added flexibility for Heavy-Duty Fast Charging Infrastructure (FCI) crediting. We also appreciate that CARB has recognized the importance of book-and-claim access for biomethane-to-electricity pathway crediting, which reflects the Board's openness to feedback from stakeholders like us.

However, we are concerned that book-and-claim accounting for electricity pathways may exclude linear generators and green hydrogen-to-electricity as an eligible pathway. As Prologis' pioneering real-world efforts to speed development of industrial charging infrastructure for heavy-duty electric fleets shows, linear generators are a critical technology to meet our customers' and the state's heavy-duty electrification goals – with similar emissions (essentially zero) as fuel cells but also immediately affordable, flexible between hydrogen- and biomethane-to-ZEV pathways, and able load-follow megawatt-level EV charging events without degradation. Linear generators are now eligible under California's Renewable Portfolio Standard (RPS) and are business critical to enterprises such as Prologis, which sees 36% of U.S. goods move through its U.S.-based facilities.[1]

Explicitly allowing book-and-claim access for green hydrogen-to-electricity pathways would provide additional flexibility for supporting the state's transportation electrification and renewable hydrogen goals. **We ask that the Board to clarify that linear generators are an eligible technology under the biomethane-to-electricity book-and-claim provisions.** We also ask that CARB enable book-and-claim accounting for green hydrogen-to-electricity pathways via hydrogen-blending gas distribution networks within California. Our feasibility assessments show warehouse rooftop solar electrolysis supplying electric vehicle charging hubs can be an economical and expedient pathway to decarbonization in California.

Linear Generators Now RPS Eligible, Like Fuel Cells

The clean emissions performance of linear generators and comparability to fuel cells was recently

[1] https://www.prologis.com/news-research/economic-impact-report

validated through AB 1921, which was signed into law by Governor Newsom last month. AB 1921 explicitly includes linear generators using renewable fuels as eligible under the state's RPS, just like fuel cells currently are. *This bill received no "no" votes throughout the process,* reflecting widespread stakeholder buy-in and strong legislative intent to promote linear generators as part of California's broader clean energy goals. **We urge CARB to align the LCFS regulations with this legislation by expressly including linear generators as eligible technology for biomethane-to-electricity crediting**.

Linear Generators: Clean Technology with Low Emissions

Linear generators, such as those developed by Mainspring and Hyliion, are clean, low-emission technologies. We understand that CARB staff have seen data comparing emissions from linear generators to those from fuel cells, which demonstrate similar criteria pollutant emissions between the technologies. Indeed, data for Prologis' Denker Avenue EV charging depot in Los Angeles shows that linear generators achieve more than 97% NOx reductions compared to diesel trucks, with minimal VOC emissions *(see appendix following letter)*. These results demonstrate the technology's potential for significant emissions reductions, particularly in applications supporting electric vehicle (EV) charging. Including linear generators in the LCFS program aligns with CARB's objectives of reducing transportation-related emissions and promoting cutting-edge, clean technologies.

As detailed in our previous comments,[2] Prologis Mobility and Performance Team, a Maersk company that operates electric vehicles across the country, recently demonstrated a unique solution to infrastructure challenges facing heavy-duty fleet operators by developing the world's largest EV charging project powered by a self-sufficient microgrid, which uses Mainspring technology with green hydrogen, renewable natural gas, and green methanol fuel flexibility.[3] The project was constructed in five months, rather than the years it would have taken otherwise (as estimated by the local utility), allowing the fleet to electrify quickly while interconnection to the electrical grid proceeds later. Once the project is directly interconnected to the grid, the added resiliency for critical EV fleet operations during periods of grid stress or power outage will be critical. The infrastructure also preserves partial infrastructure flexibility for expanding to support fuel cell vehicles in the future. This is a replicable model that can serve to accelerate progress toward the State's ZEV goals.

The ability to use renewable fuels, such as biomethane or renewable hydrogen, would further align these projects with California's climate goals. Explicitly including linear generators would provide additional market clarity and flexibility to support the use of this pioneering model to overcome infrastructure challenges that hinder CARB's transportation electrification goals. Similarly, allowing for book-and-claim access for renewable hydrogen-to-electricity pathways would provide additional optionality and cost savings to support resilient, renewable EV charging.

Critical technoeconomic risk mitigations of linear generators

Linear generators offer critical real world operational risk mitigations that make them especially important tools for EV charging infrastructure:

- **Cost-Effective**: Linear generators today are 25%-50% the capital cost of commercially available fuel cells. They also last for 20 years and do not degrade which results in significantly lower

[2] https://www.arb.ca.gov/lists/com-attach/7539-lcfs2024-VDdSNVMgUmMHXgBi.pdf
[3] https://www.prologis.com/insights/success-stories/north-americas-largest-heavy-duty-ev-charging-hub-powered-microgrid

maintenance and lifecycle costs of electricity for our customers.

- ZEV pathway flexible: Linear generators can handle the volatility and nascency of green fuel markets today by allowing fuel switching from one green fuel to another green fuel during times of supply chain stress for the incumbent. For example, the margin for error is unacceptably small in operations that use fuel cells for the next few years while green hydrogen supply chains are in infancy.
- Dispatchable: Linear generators are genuinely dispatchable machines. For a business with many challenging load profile cases this makes their selection simple and makes designs and maintenance programs transferable from one site to the next.
- Efficient: Linear generators have exceptional fuel efficiencies that are competitive, predictable and do not degrade. This is critical for low lifecycle costs of electricity for our customers.

These features, along with their low emissions profile, make linear generators an ideal fit for California's LCFS book-and-claim program.

Conclusion

We strongly support the LCFS and greatly appreciate CARB's continued leadership in refining the program to support the State's transportation electrification goals and foster growth of low-carbon technologies. By explicitly including linear generators in the program, CARB can further accelerate the deployment of low-emission EV charging infrastructure and align the program with the AB 1921 statute. We look forward to continuing to collaborate with CARB to meet California's ambitious climate goals. The exact changes we request are shown below the signatures.

Thank you for considering these comments and recommendations.

Respectfully submitted,

Alexis Moch
Vice President, Government Affairs
Prologis

Bobby K. Cherian
Senior Vice President, Government Affairs
Hyliion Inc

Kent Leacock
Senior Director, Public Affairs
Mainspring

Allie Detrio
Senior Advisor
Microgrid Resources Coalition

Section §95488.8(i)(2):
Book-and-Claim Accounting for Pipeline-Injected Biomethane Used as a Transportation Fuel, to Produce Electricity for EV Charging, or to Produce Hydrogen. Indirect accounting may be used for RNG used as a transportation fuel, to produce electricity using a fuel cell, including a linear generator, for EV charging, or to produce hydrogen for transportation purposes (including hydrogen that is used in the production of a transportation fuel), provided the conditions set forth below are met:

(A) RNG injected into the common carrier pipeline in North America (and thus comingled with fossil natural gas) can be reported as dispensed as bio-CNG, bio-LNG, or bio-L-CNG, or to produce electricity using a fuel cell, including a linear generator, for EV charging, or as an input to hydrogen production, without regards to physical traceability. Entities may report natural gas as RNG within only a three-quarter time span. If a quantity of RNG (and all associated environmental attributes, including a beneficial CI) is pipeline-injected in the first calendar quarter, the quantity claimed for LCFS reporting must be matched to natural gas sold in California as RNG no later than the end of the third calendar quarter. After that period is over, any unmatched RNG quantities expire for the purpose of LCFS reporting.

(B) Biomethane reported under fuel pathways associated with projects that break ground after December 31, 2029, injected into the common carrier pipeline, and claimed indirectly under the LCFS program for use as bio-CNG, bio-LNG, or bio-L-CNG in CNG vehicles, or to produce electricity using a fuel cell, including a linear generator, for EV charging, or as an input to hydrogen production must demonstrate compliance with the following requirements:

1. Starting January 1, 2041, for bio-CNG, bio-LNG and bio-L-CNG pathways, and January 1, 2046, for biomethane used to produce electricity using a fuel cell, including a linear generator, for EV charging, or as an input to hydrogen production, the entity reporting biomethane must demonstrate that the pipeline or pipelines along the delivery path physically flow from the initial injection point toward the fuel dispensing facility at least 50 percent of the time on an annual basis. Notwithstanding the above, if the number of unique Class 3-8 ZEVs reported or registered in California exceeds 132,000 ZEVs or NZEVs on December 31, 2029, based on the evaluation and notification specified by subsection 95488(d)(1), then the entity reporting under bio-CNG, bio-LNG and bio-L-CNG pathways for CNG vehicles must demonstrate the physical flow listed above after December 31, 2037. Entities may report natural gas as RNG within only a three-quarter time span. If a quantity of RNG (and all associated environmental attributes, including a beneficial CI) is pipeline-injected in the first calendar quarter, the quantity claimed for LCFS reporting must be matched to natural gas sold in California as RNG no later than the end of the third calendar quarter. After that period is over, any unmatched RNG quantities expire for the purpose of LCFS reporting.

(C) To substantiate RNG quantities injected into the pipeline for dispensing as bio-CNG, bio-LNG, or bio-L-CNG, or to produce electricity using a fuel cell, including a linear generator for EV charging, or as an input to hydrogen production, the pathway application and subsequent Annual Fuel Pathway Reports must include the following documents linking the environmental attributes of RNG (in MMBtu or Therms) with corresponding quantities of natural gas withdrawn:

1. Unredacted monthly invoices showing the quantities of RNG (in MMBtu) sourced and the contracted price per unit;

2. Unredacted contract by which the fuel pathway holder obtained the environmental attributes.

(D) Starting January 1, 2041, for bio-CNG, bio-LNG and bio-L-CNG pathways (unless the accelerated timeline is activated by the criteria described in section 95488.8(i)(2)(B)1.), and January 1, 2046, for biomethane used to produce electricity using a fuel cell**, including a linear generator** for EV charging, or as an input to hydrogen production, to substantiate RNG quantities injected into the pipeline for biomethane fuel pathways associated with projects that break ground after December 31, 2029, the pathway application and subsequent Annual Fuel Pathway Reports must include the documents required by section 95488.8(i)(2)(C) as well as the following documents.

1. Monthly pipeline nomination reports for each pipeline along the delivery path.

Section §95488.8(i)(3)(A):

(A) Low-CI hydrogen is injected into a ~~dedicated hydrogen~~ pipeline physically connected to California.

Table 8. Temporary Pathways for Fuels with Indeterminate CIs

Fuel	Feedstock	Process Energy	CI (gCO2e/MJ)
Low-CI electricity produced by fuel cell or linear generator	Biomethane from Dairy and Swine Manure	N/A	-300
Low-CI electricity produced by fuel cell or linear generator	Electrolysis of Water using zero-CI or Negative-CI electricity	N/A	110

Appendix – Comparison of Emissions of Alternative technologies at Denker

MEMORANDUM

June 28, 2024

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.