



October 11, 2022

To whom it may concern,

Lime (Neutron Holdings, Inc.), a global leader in shared micromobility, offering electric scooter and electric assist bike rentals in nearly 30 countries around the world, would like to participate in the California Air Resources Board's Low Carbon Fuel Standard (LCFS) program.

As it stands today, the LCFS regulation does not have an applicable Energy Economy Ratio (EER) for Lime's micromobility equipment types or a carbon intensity score for its equipment charging. Therefore, we respectfully request your review of the following Tier 2 pathway, which outlines an EER for electric scooters and electric bicycles and an updated carbon intensity score.

We believe opening a micromobility pathway in the LCFS program helps continue to advance this valuable transportation mode and its benefits.

Micromobility equipment has established itself as an important emission-reducing first- and last-mile solution across California. Incorporating micromobility into the LCFS program demonstrates California's commitment to supporting and encouraging cleaner transportation solutions for its communities.

Certain information in the application is a trade secret and is exempt from disclosure under the California Public Records Act. As such, we have provided a copy of our application with trade secrets redacted and we authorize release of this redacted version in the event that the agency receives a public records request.

Thanks,

A handwritten signature in black ink, appearing to read "Andrew Savage", with a long horizontal line extending to the right.

Andrew Savage
VP, Head of Sustainability

**Carbon Commodities Group
Lime**

California Air Resources Board - Low Carbon Fuel Standard
11.Oct.2022

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Pathway summary

Carbon Commodities Group is pleased to submit this Low Carbon Fuel Standard Tier 2 pathway application for electric micromobility equipment (e-scooters and e-bikes) on behalf of Lime, which, when implemented, will continue to drive lower emissions in California. Accepting the proposed pathway and its adjusted EER and carbon intensity score will encourage greater e-mobility adoption and enable micromobility companies to invest their LCFS generated funds into cleaner operational vehicles to further reduce associated emissions.

Lime owns and operates fleets of on-demand electric mobility equipment including e-scooters and e-bikes in many California cities, including Los Angeles, Sacramento, San Francisco, San Jose, and other communities. This e-mobility equipment is often used as a transportation alternative to light-duty gasoline vehicles.¹ Logistically, Lime's fleet operation is most commonly enabled by using commercial vans to rebalance asset locations and transport e-scooters for charging.

The following report details the data that demonstrates how operating e-scooters and e-bikes in San Francisco reduces carbon emissions. Using the methodology outlined in this pathway, Lime estimates its micromobility equipment will reduce approximately ██████████ metric tonnes of CO₂e emissions per year. This estimate is based on operational data from January through September of this year (2022).

The January start date was chosen for the analysis because it is when Lime made a switch to swappable e-scooters and e-bike battery operations. E-scooter and e-bikes' batteries can be exchanged in the field for recharging as opposed to the traditional method of retrieving the vehicles, transporting them to a central depot for charging, and then re-deploying them once recharged.

Lime currently has swappable battery vehicles in San Francisco and therefore only included San Francisco operations for this application. Lime is currently in the process of converting its other fleets to swappable batteries but did not include these equipment and cities in this analysis. Lime plans to add operations from other cities as Lime's fleet of swappable battery e-scooters and e-bikes grows and expands to new cities in accordance with the methodology outlined here.

In cities where Lime operates both e-bikes and e-scooters, operations are effectively indistinguishable between the two vehicle types because the batteries are interchangeable. Separating the two vehicle types into separate pathways would require assumptions about Lime's operations that would be difficult, if not impossible, to implement or justify, thus Lime's application combines the e-scooters and e-bikes into a single methodology. As Lime adds new cities it will include operations from e-bikes as well as e-scooters.

The methodology used to determine the Carbon Intensity (CI) of e-scooter and e-bike vehicles is based upon the framework of the light-duty electric vehicle pathway created by CARB. The approach applies an appropriate Energy Economy Ratio (EER) for the e-scooter/e-bike and incorporates the emissions associated with the gasoline used by the vans used by Lime for its fleet management and operations.

¹ San Francisco Municipal Transportation Agency, Powered Scooter Share Mid-Pilot Evaluation, [report](#) and [appendices](#)

Fuel Life Cycle



Site-Specific inputs

Working with the California Air Resources Board, Lime identified several site-specific inputs that drive the EER and operational emission calculations. The site-specific inputs for this application are:

1. **electricity consumption in e-scooters and e-bikes** (kWh),
2. **e-scooter and e-bike distance traveled** (km),
3. **internal task data** (qty), and
4. **gasoline consumed by vans** (gallons)

Below we provide more details around how we collect and arrive at the values for these inputs.

E-scooters and e-bikes as meters: IoT telemetry overview

Lime e-scooters and e-bikes rely on Internet-of-Things (IoT) telemetry technology to provide regular status updates when in operation [REDACTED]

[REDACTED] The devices also instantaneously record the vehicle status when certain events, such as electric charging, occur or are performed on them. [REDACTED]

Electricity consumption in e-scooters and e-bikes (kWh)

To calculate the energy consumption of swappable e-scooters and e-bikes, we queried Lime's database, specifically looking at data related to all charging events. We filtered the data to only include charging events for swappable e-scooters in San Francisco between January 1 and September 30, 2022. To calculate the percent battery charge increased by the charging event, we subtracted the battery charge (as a percentage of total capacity) reported at the beginning of charging from the battery charge at the end of charging. Since the resulting metric is a percentage of total battery capacity, we then multiplied the percent charged by the vehicle's battery capacity (in kWh) to calculate the kWh of electricity used in each individual charging event. We then summed the kWh of battery charging across all charging events in San Francisco for swappable e-scooters between January 1 and September 30, 2022 to determine the total electricity consumption for vehicle charging over that time period.

E-scooter and e-bike distance traveled (km)

To calculate total e-scooter and e-bike distance traveled, we again queried Lime's central database, analyzing data from a table summarizing the details of each e-scooter and e-bike trip taken. [REDACTED]

[REDACTED] From this table of records, we then filtered the table to only include trips taken on swappable e-scooters in San Francisco. We summed up across all records to determine the total distance traveled by swappable e-scooters between January 1 and September 30, 2022.

Van gasoline consumption methodology

[REDACTED]

[REDACTED]

[REDACTED] Lime estimated total gasoline consumption by leveraging data from its San Francisco operations, where Lime has handled all rebalancing and charging needs internally [REDACTED]

Internal task data (qty)

Lime used task data to extrapolate gasoline usage [REDACTED]

Task data provides the type of task a piece of equipment is undergoing such as retrieving an

e-scooter or e-bike, charging a vehicle, and re-deploying a vehicle. [REDACTED]

Gasoline consumed by vans (gal)

[REDACTED]

[REDACTED]

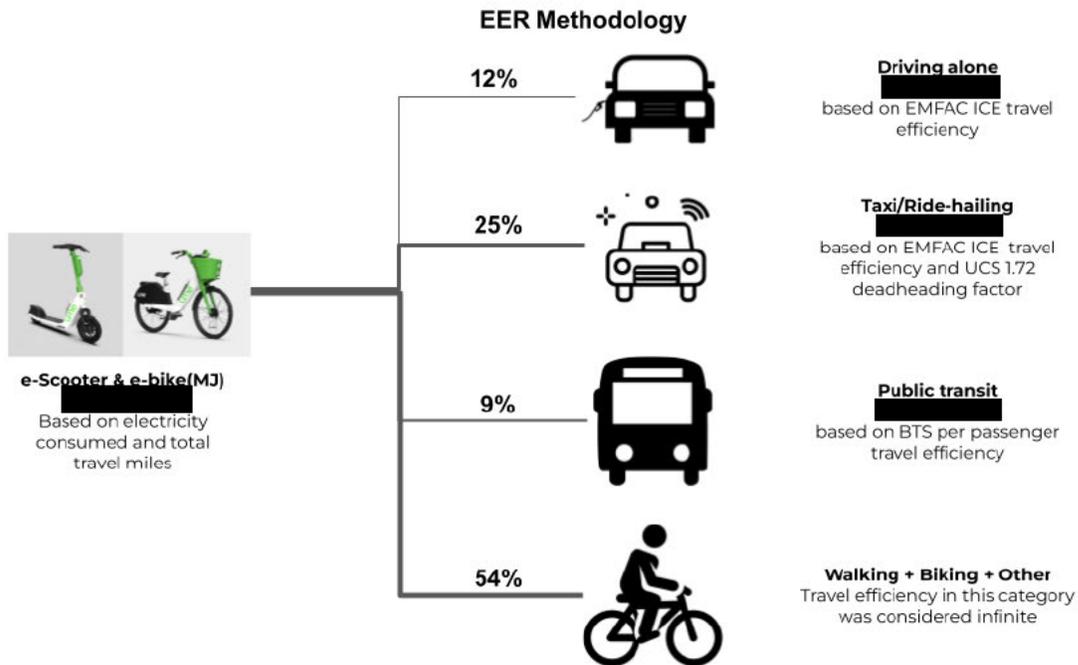
Lime will calculate a gas-consumption-per-task factor using San Francisco as its basis. This will be done by taking total gasoline usage [REDACTED] and dividing by the operations tasks completed over that period.

For mixed operation cities, when Lime needs to extrapolate to determine total gasoline usage, Lime will calculate the total gallons of gasoline consumed by multiplying the San Francisco gas-to-task ratio by the total tasks completed in the specific city.

Energy Economy Ratio (EER)

To calculate an Energy Economy Ratio for shared e-scooters and e-bikes, Lime compared the per-passenger travel efficiency of an e-scooter and e-bike to the per-passenger travel efficiency of relevant alternative modes of transportation.

Lime reviewed several electric micromobility reports, surveys, and studies to determine the appropriate mode shift percentages for e-scooters and e-bikes. From this literature review and based upon CARB's recommendations it chose four large, representative surveys from Californian cities it has operated in: San Francisco ([report](#) and [appendices](#)), Los Angeles ([report](#)), Oakland ([report](#) and [survey responses](#)), and Sacramento ([report](#)). The four cities' surveys have a combined sample size of 12,484 survey respondents, and averaging across the four cities we calculate that 25% of e-scooter or e-bike trips replace taxi or ride hailing, 12% replace driving alone, 9% replace public transit, and 54% replace walking, biking, and various other modes.



E-scooter and e-bike travel efficiency

To determine the travel efficiency of its swappable e-scooters and e-bikes, Lime collected fleet data from January 1 to September 30, 2022. Using this data, and the 3.6 MJ per kWh constant, we determined that an e-scooter and e-bike can travel [REDACTED] km per MJ.

Travel efficiency of driving alone in a light-duty vehicle (LDV)

To determine the travel efficiency of driving alone in a LDV, Lime used 44.1 km per gallon based on CARB's Emission Factor (EMFAC) model². This figure was then divided by the energy density of gasoline of 115.8 gal per MJ (based on CaRFG) to arrive at a per-passenger travel efficiency of [REDACTED] km per MJ.

Dividing the e-scooter & e-bike energy efficiency by the drive alone energy efficiency, we calculate an EER value of [REDACTED].

Travel efficiency of riding alone in a ride-hailing vehicle

To determine the travel efficiency of traveling alone in a ride-hailing vehicle, Lime divided the travel efficiency of driving alone in an LDV [REDACTED] by a dead heading factor of 1.72

² EMFAC 2017 model ([source](#)): The average mpg across the LDA, LDT1, and LDT2 categories (passenger cars and light duty trucks) for California statewide 2020 gas vehicles is 27.4, using EMFAC 2011 categories, aggregated model years, and aggregated speeds. This converts to 44.1 km per gallon.

determined by the Union of Concerned Scientists³. This method was used to account for the additional travel and therefore energy consumed to support the trip and results in a travel efficiency of [REDACTED] km per MJ.

By dividing the e-scooter & e-bike energy efficiency by the taxi and ride-hailing energy efficiency, we calculate an EER value of [REDACTED]

Travel efficiency of public transit

Based on values of 2,760 BTU per passenger mi from published BTS statistic tables and conversion constants to convert BTU to MJ and mi to km, we calculate that the average replaced public transit trip travels [REDACTED] km per MJ.

By dividing the e-scooter & e-bike energy efficiency by the public transit energy efficiency, we calculate an EER value of [REDACTED]

Alternative modes of transportation

We consider all other replaced modes, such as walking or riding a bicycle as having essentially infinite energy efficiencies, since they consume no transportation fuels during the use phase. Therefore, the EER value when comparing scooters and these other fuel-free modes is 0.

Blended EER

To calculate the blended EER, we take each individual, mode-specific EER and multiply it by its associated mode shift to calculate a weighted, blended value for e-scooters and e-bikes as a whole [REDACTED]

Carbon intensity of e-scooters and e-bikes

To determine the carbon intensity of Lime's operations, the team calculated the emissions associated with the electricity to charge the swappable e-scooters and e-bikes and the emissions associated with vans used to rebalance, swap batteries, and transport equipment to centralized locations for maintenance.

Emissions associated with electricity directed to e-scooters and e-bikes

Because Lime is already buying renewable energy for all e-scooter and e-bike charging (and thus travel usage), we considered electricity to the e-scooters and e-bikes as adding no more emissions to the pathway. Lime intends on using book-and-claim accounting for indirectly supplied zero-CI electricity. The electricity directed to Lime's e-scooters and e-bikes will therefore have a carbon intensity score of 0 gCO₂e/MJ.

³ Union of Concerned Scientists, Ride-Hailing's Climate Risks calculates that the "average TNC ride was 72% longer than the fraction of the trip with passengers." ([source](#))

Emissions associated with van operations

Lime leveraged the gasoline usage detailed in the *Gasoline consumed by vans* section above to determine the total emissions associated with its operations amount of gasoline consumed in vans per kilometer traveled by e-scooters and e-bikes.

Using constants (115.83 MJ per gallon from CaRFG & 99.44 gCO2e per MJ of gasoline) and previously calculated operational figures, we calculate the gasoline consumed for Lime operations between January 1 and September 30, 2022 in grams of CO2.

Dividing this by the e-scooter and e-bike’s energy consumption (in MJ) results in a per-vehicle energy input ratio of [redacted] gCO2e/MJ.

Credit generation estimates

Using the EER, carbon intensity score, mode shift factor, and CARB’s credit calculation formula, Lime estimates that [redacted] MT of CO2e were avoided between January 1 and September 30, 2022 and therefore that many LCFS credits would have been created.

In accordance with the LCFS regulation, only electricity used to displace gasoline usage is considered in the calculation of credits. To adjust for this requirement, we reduce the overall e-scooter and e-bike electricity usage for the relevant period by the combined mode shift amount of 46% (12% driving alone + 25% ride hailing + 9% public transit) detailed above in the Energy Economy Ratio (EER) section.

$$Credits = (CI_{standard} - CI_{eScooter} / EER) \times Energy\ Density \times EER \times Electricity\ Usage \times 10^{-6}$$

The formula uses the following definitions:

- EER = [redacted]
- CI Standard = 89.5 gCO2e/MJ (2022)
- CI eScooter = [redacted] gCO2e/MJ
- Electricity Usage = 46% * [redacted]
- Energy Density = 3.6 MJ/kWh
- Credits = Credits allocated in Metric tons

These calculations are further detailed in the R script included in the application package.

Quarterly reporting and facility registration

To ensure data accuracy in registration and reporting, the Lime team proposes registering Lime charging facilities (i.e., warehouses) as consolidated fuel supply stations in the cities the company serves. The facilities will be registered by providing the name, address, and latitude/longitude coordinates. All e-scooters and e-bikes assigned to that facility, whether charged by Lime or LPs, will be logged and reported to CARB on an annual basis. Registration of equipment will include the make, model, and a unique identifier per vehicle.

On a quarterly basis, Lime will aggregate electricity usage data for the e-scooters and e-bikes and gasoline usage from its van operations for the relevant time period and will submit this to CARB for each registered charging facility.

Continuous improvement

Lime is committed to improving the sustainability of its business and intends on using the framework outlined above as a tool to further align the company's business and sustainability goals.

We expect to submit additional pathways as e-scooter and e-bike travel efficiency increases and their associated emissions continue to decrease.

We look forward to expanding our role as a leader in the micromobility space and utilizing this program to advance cleaner transportation for communities across California.