

First-Last Mile Life Cycle Assessment of Transit in Los Angeles

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Outline

- Project overview and motivation
- Background & literature review
- Methodology overview
- Life cycle impacts (per passenger mile)
- Multimodal impacts (per passenger trip)
- Discussion
- Scenarios for improvement



Motivation

- There is a strong understanding of the environmental impacts from unimodal trips.
- There is limited knowledge of the environmental impacts from multimodal trips.
- Very limited knowledge of the impacts from automobile first-last mile trips in multimodal transit.

Research Questions

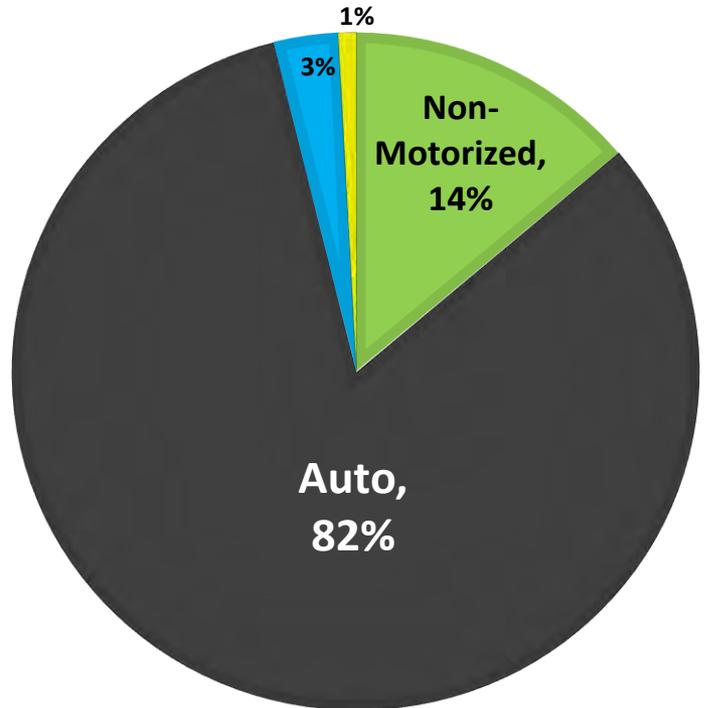
1. What effects do auto access and egress have on greenhouse gas (GHG) emissions and criteria air pollutants (CAP) in multimodal transit trips?
2. Are multimodal transit trips with auto access or egress still effective in reducing environmental impacts?
3. How do multimodal transit emissions with auto access or egress compare to a competing auto trip?

Literature Review

	Mathez et al. (2013)	Chester & Cano (2016)
Comprehensive LCA	No	Yes
Uses comprehensive travel survey data	Yes	Partially
Evaluates competing and first-last mile auto trips	Partially	Yes
Limitations	GHG average factors only, assumes Metro (Hydro power) is 0 g CO ₂ e/mi	Only one transit line, travel statistics could be improved

Modal Split in LA

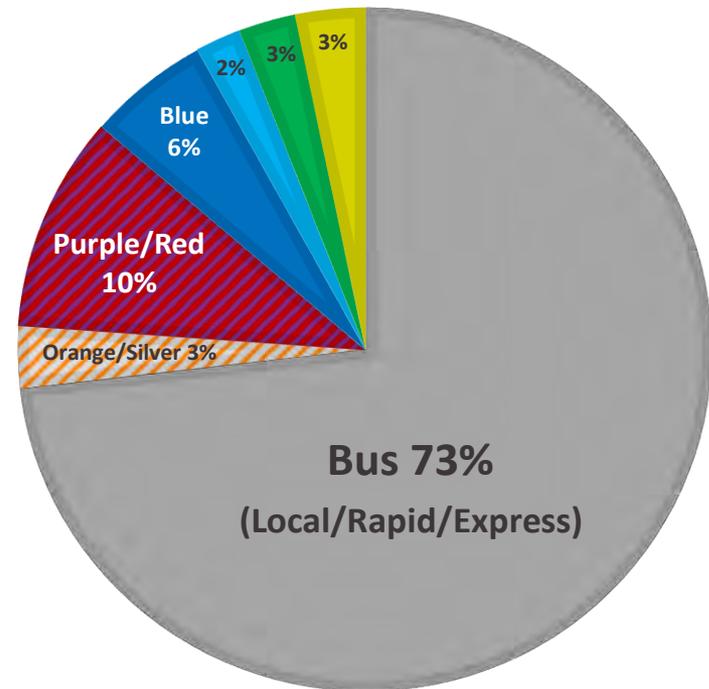
2012 LA Modal Split



■ Non-Motorized ■ Auto ■ Metro Transit ■ Other

Estimate via California Household Travel Survey
(Caltrans, 2013)

LA Metro 2014-'16 Modal Split



■ Bus ■ BRT ■ Heavy Rail ■ Blue ■ Expo ■ Green ■ Gold

Estimate via boardings
(LA Metro, 2016)

Methodology Overview

- Assess impacts for **near-term peak, off-peak, and average** time-of-day travel.
- Estimate **average long-term** impacts using future energy mixes, transit growth, improvements to technology, etc.
- Assess both greenhouse gas (GHG) emissions and criteria air pollutants (CAP).
- **First:** Develop LCA framework and estimate **per passenger-mile impacts** for all modes at all times of day.
- **Second:** Develop **per trip impacts** with auto access/egress travel characteristics.

Data & Tools

Trip Characteristics:

- California Household Travel Survey (CHTS, 2012-13)
- LA Metro On-board Surveys (2013 – current)

Operational data:

- Ridership & Operation Reports (2013 – current)

Infrastructure data:

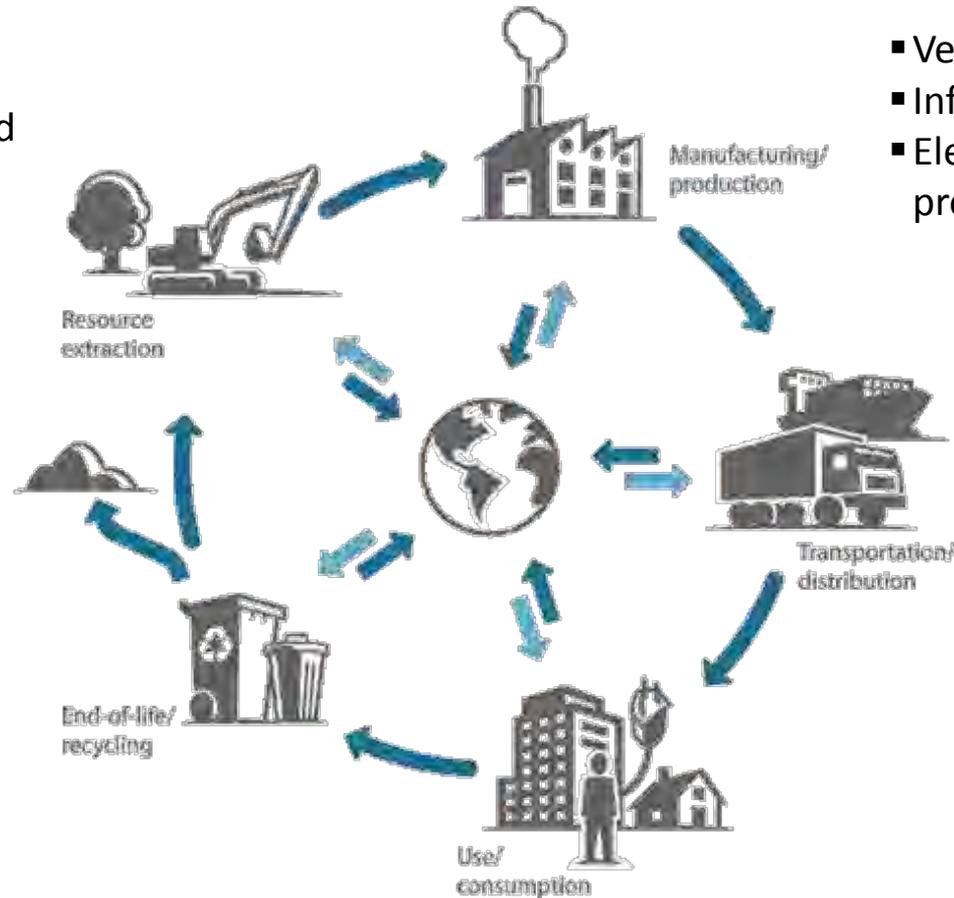
- Engineering design documents, Google Earth

LCA Framework:

- Approach includes use of SimaPro, GREET, PaLATE, plus other components

Life Cycle Scope

- Raw material and fuel extraction and processing

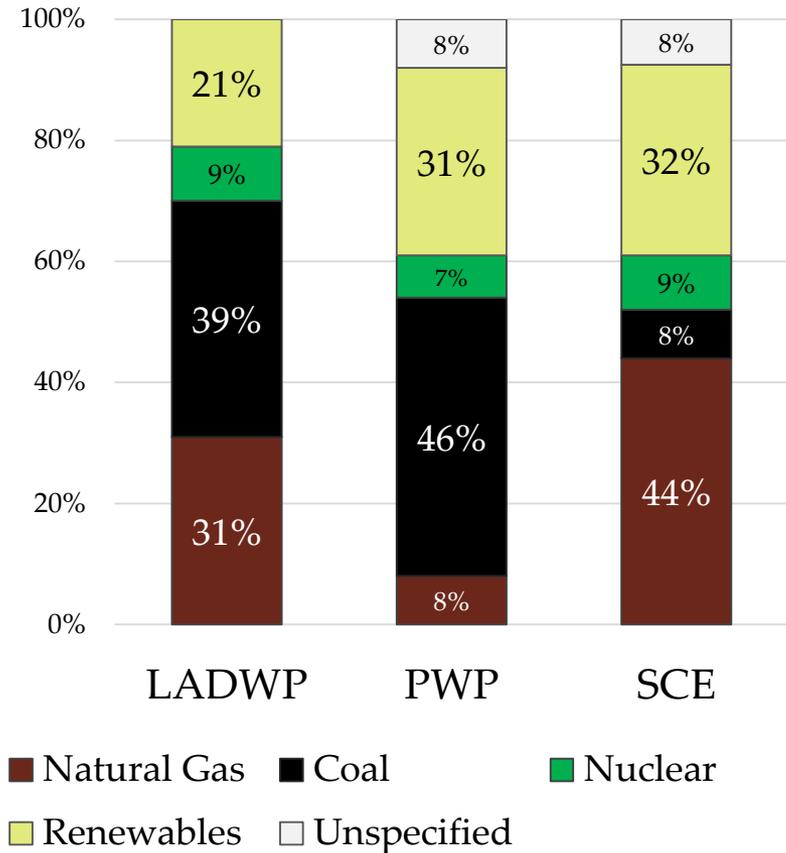
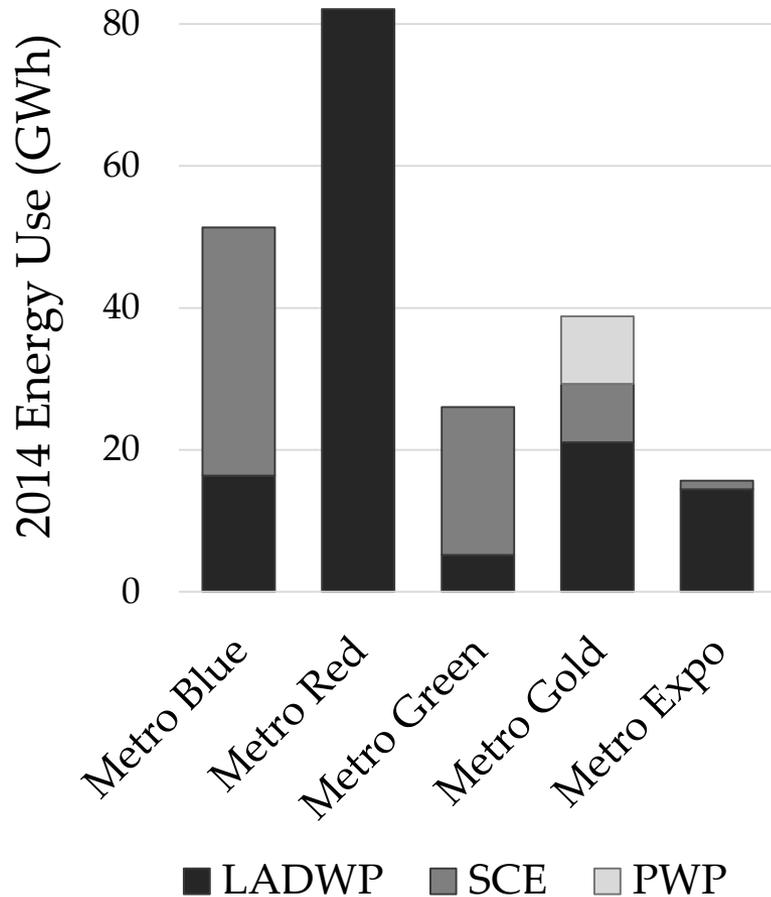


- Vehicle manufacturing
- Infrastructure construction
- Electricity production/generation

- Transport to point of sale
- Electricity transmission and distribution

- Vehicle operation & maintenance
- Infrastructure operation & maintenance

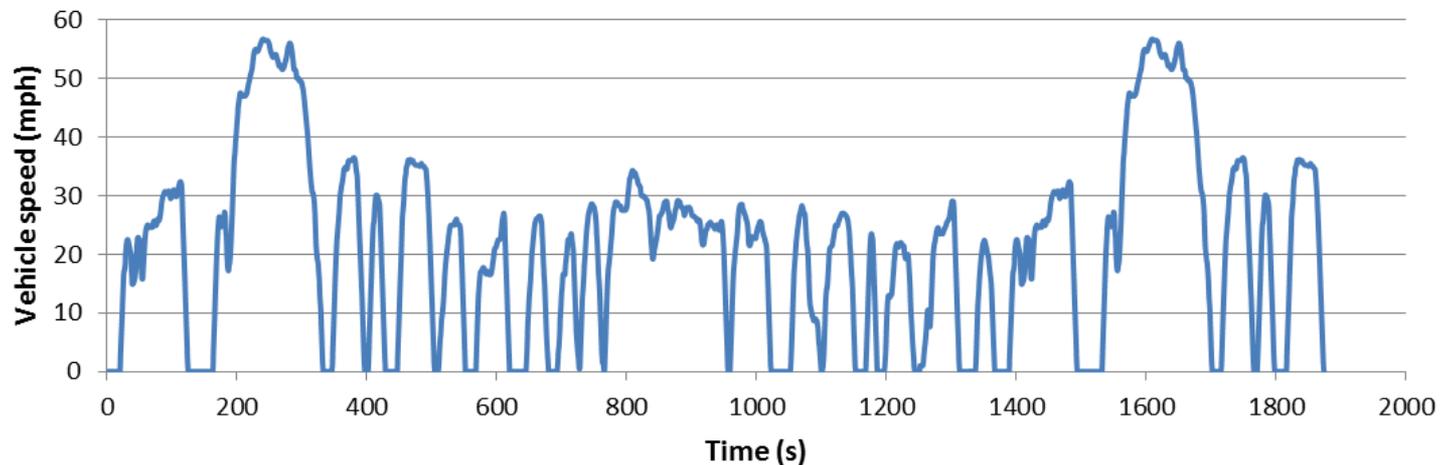
Metro Rail Energy Use



Reflects the approx. mix of energy supplied from 2013-2014.

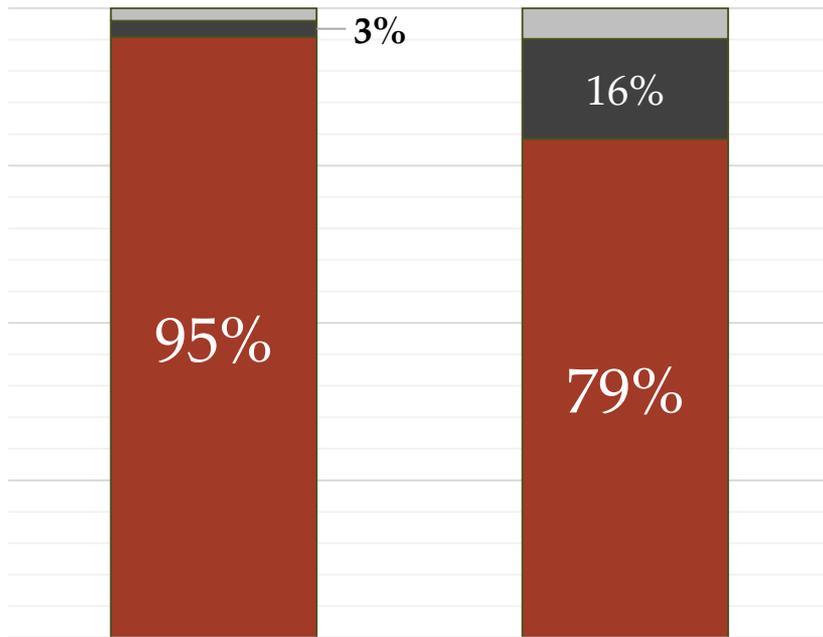
Bus & Metrolink Drive Cycles

- Local, Express, and Rapid Bus drive cycles were estimated by matching similar cycles in similar buses (excluding Orange BRT).
- Estimated system fuel consumption (based on VMT) was 4% lower for buses, and 7% lower than locomotives.
- Metrolink drive cycles developed from similar locomotive operation impacts from Fritz (1994).



First-Last Mile in LA

Access & Egress Modes (2012-13 CHTS)

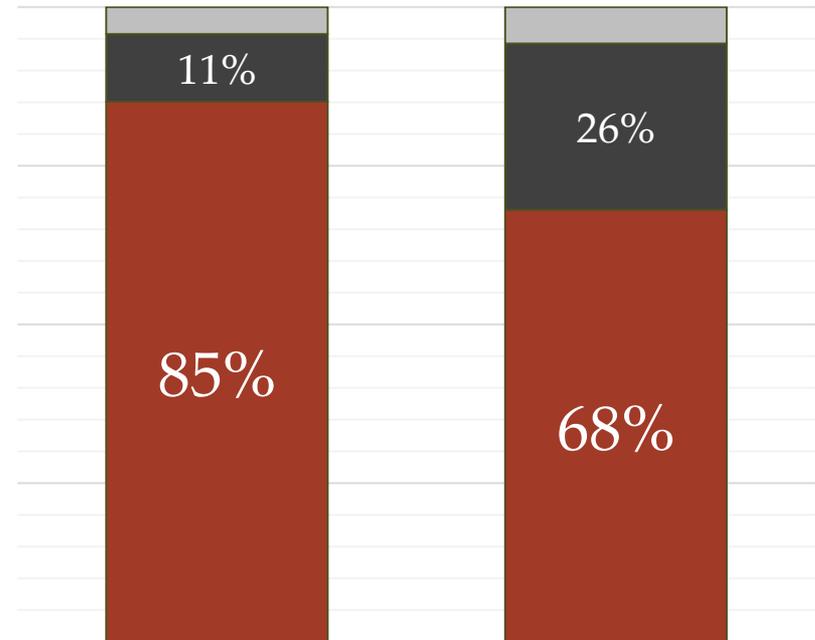


Metro Bus

Metro Rail

■ Walk/Bike ■ Auto ■ Other

Access Mode (2012-13 Metro Surveys)



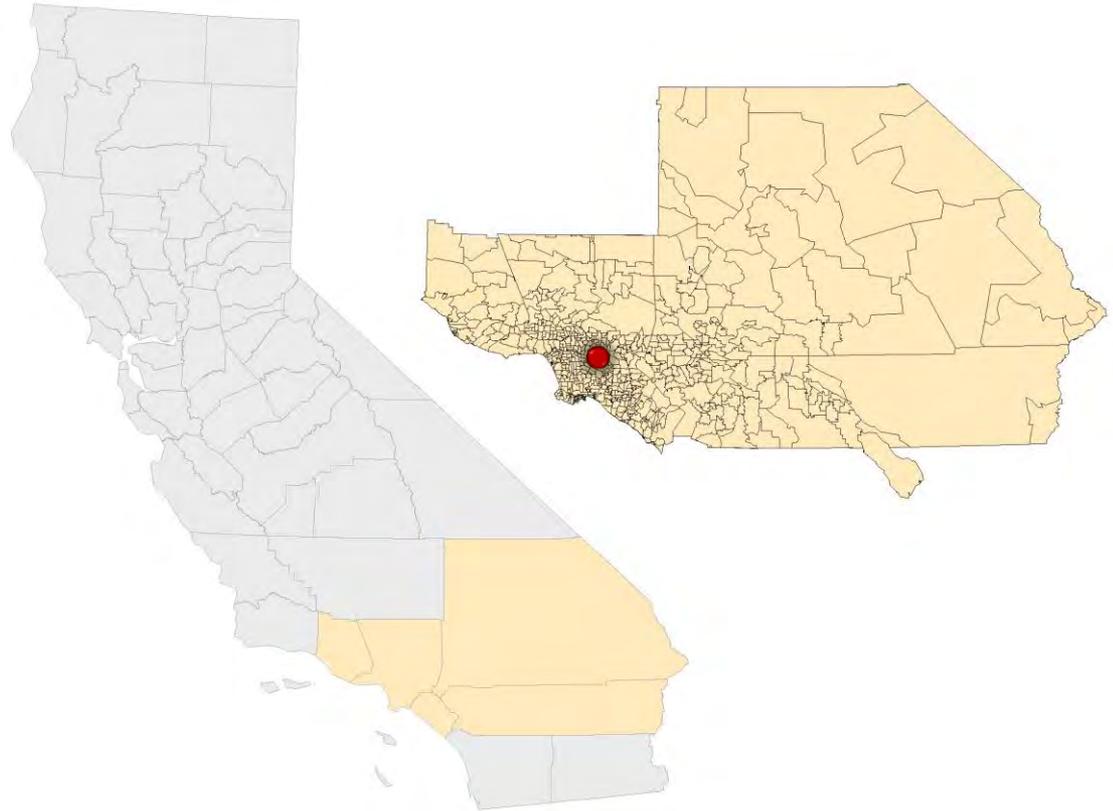
Metro Bus

Metro Rail

■ Walk/Bike ■ Auto ■ Other

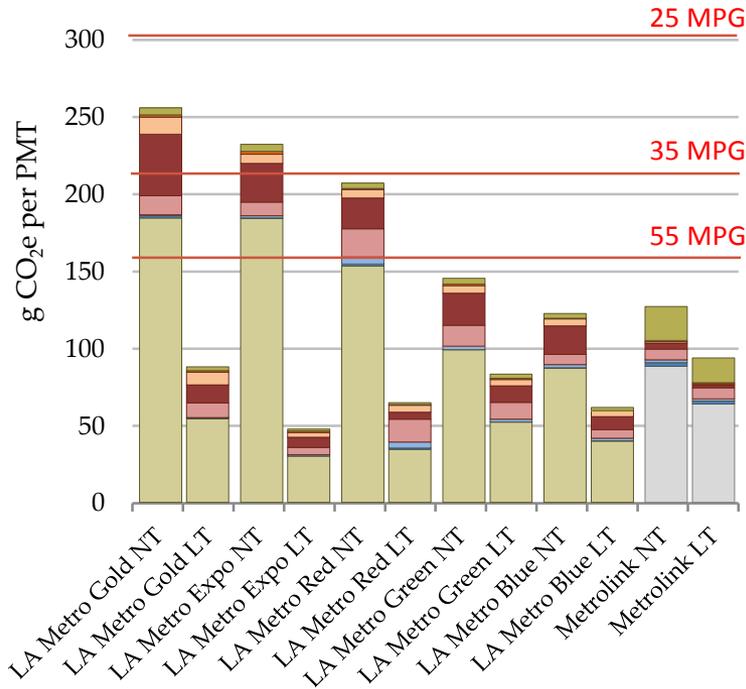
Trip Characteristics (CHTS)

- Trip characteristics determined for each region/transit system.
- Aggregation at the zip code level, over 900 sub-regions.
- Auto trips are shorter distance than transit for same ODs.

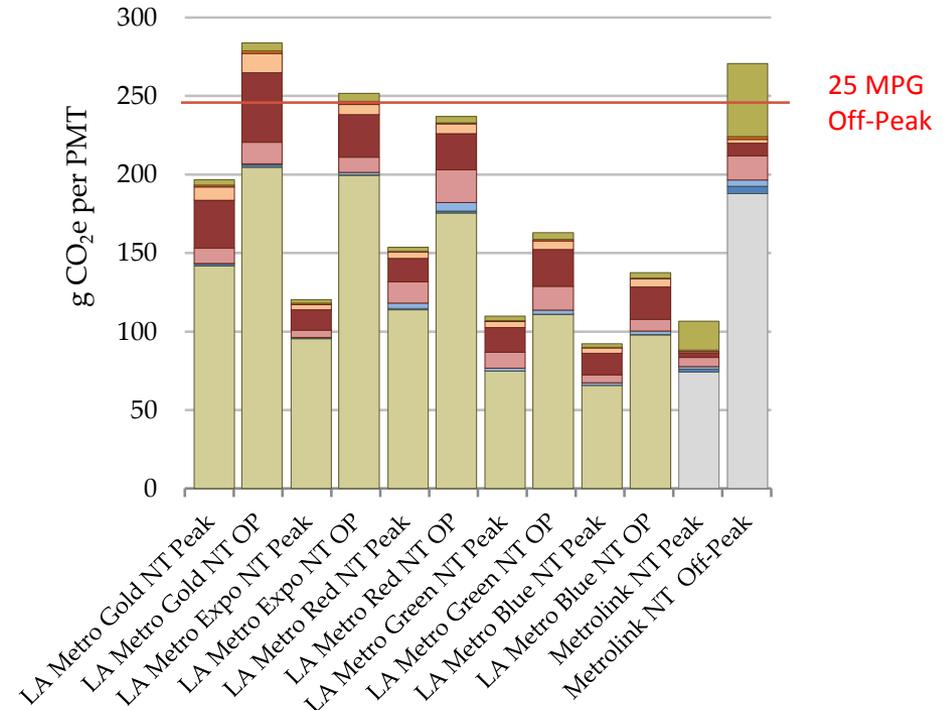


Rail GHG Emissions per PMT

Near Term vs. Long Term



Peak vs. Off-Peak

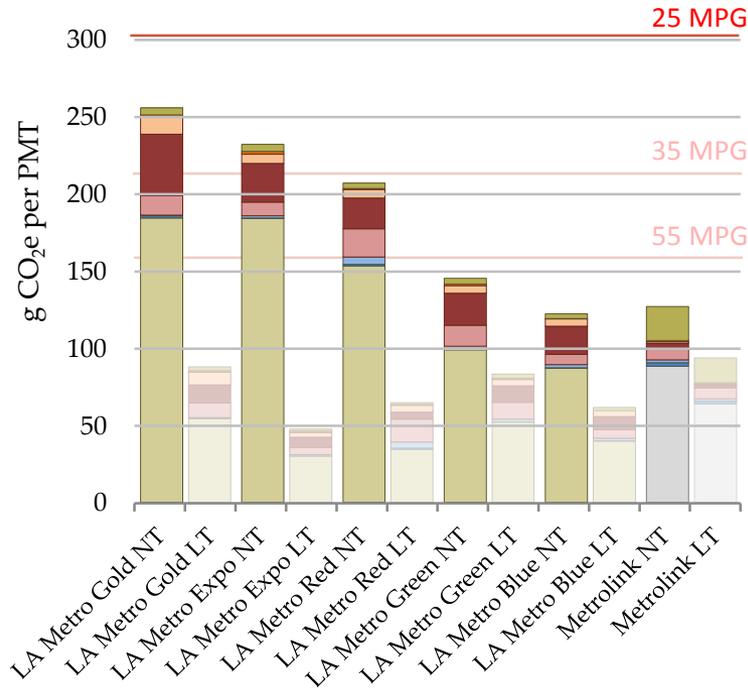


- Fuel Combustion
- Propulsion Electricity
- Vehicle Manufacturing
- Vehicle Maintenance
- Batteries
- Infrastructure Construction
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- Infrastructure Parking
- Energy Production

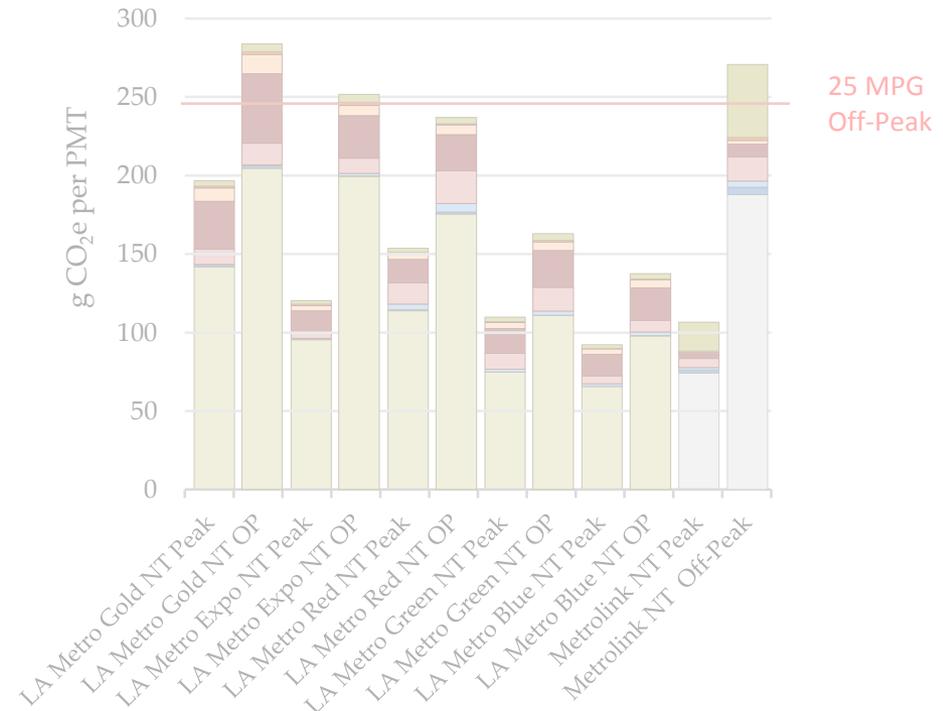
**Note: Sedan is 2 passengers*

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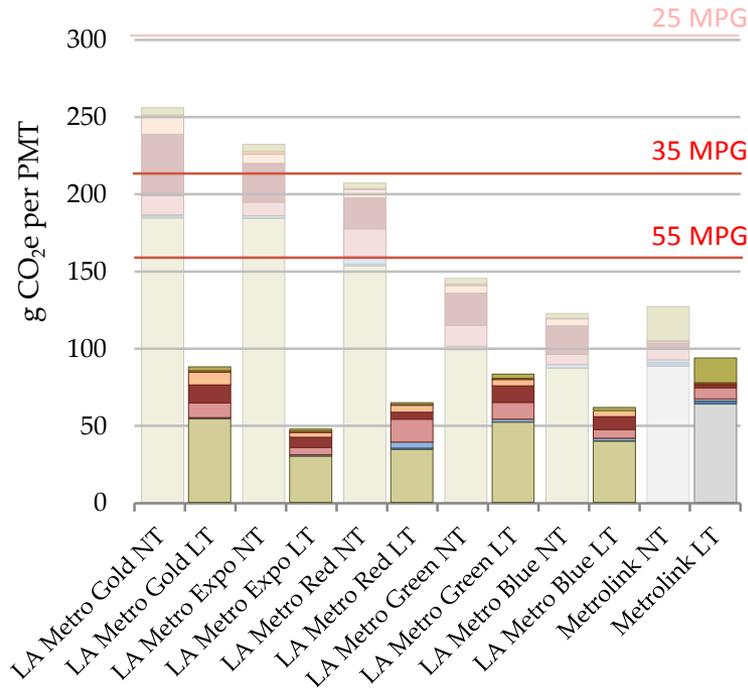


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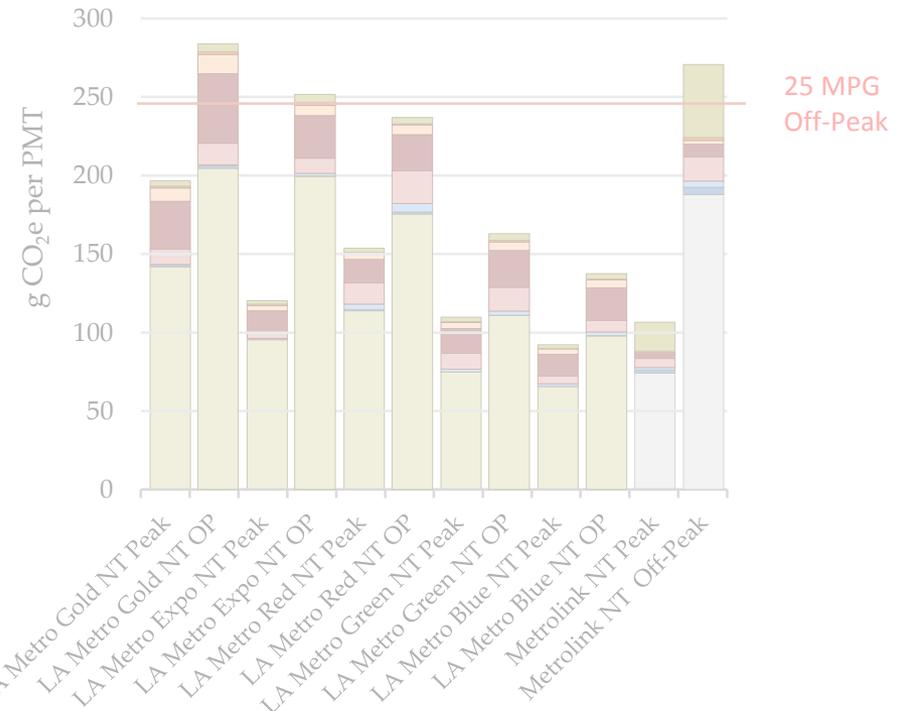
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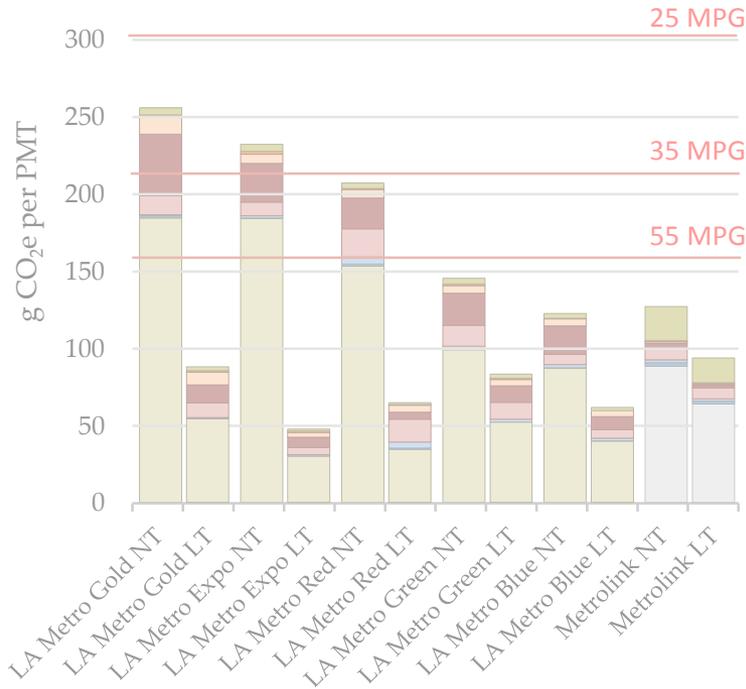


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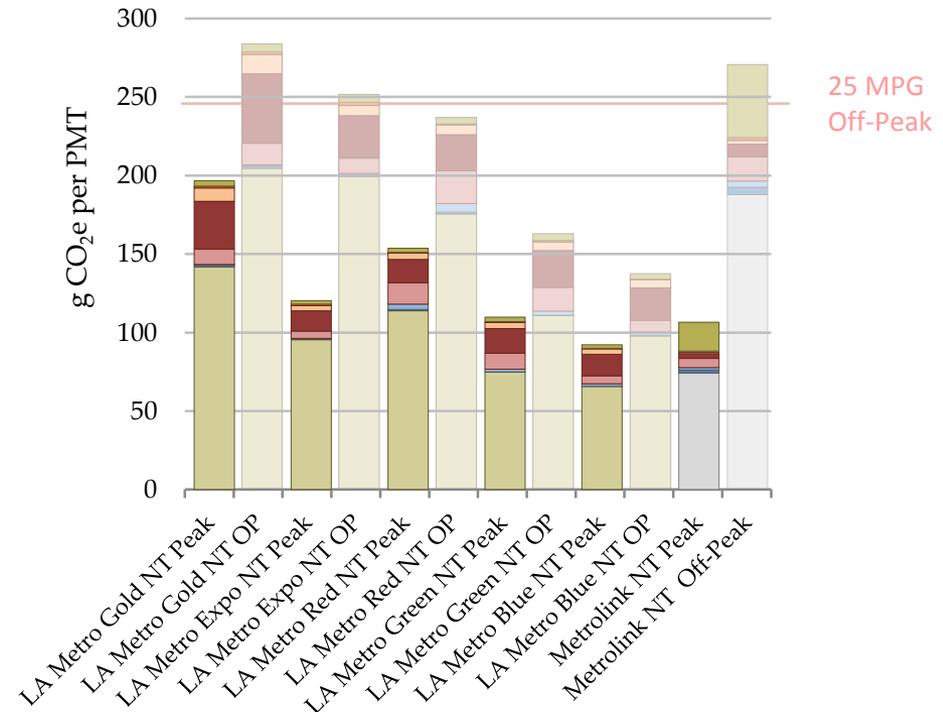
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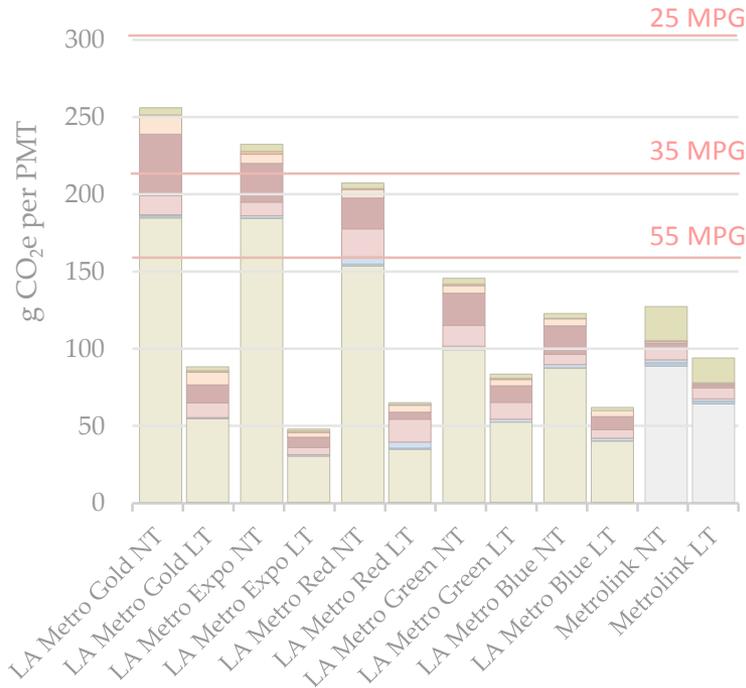


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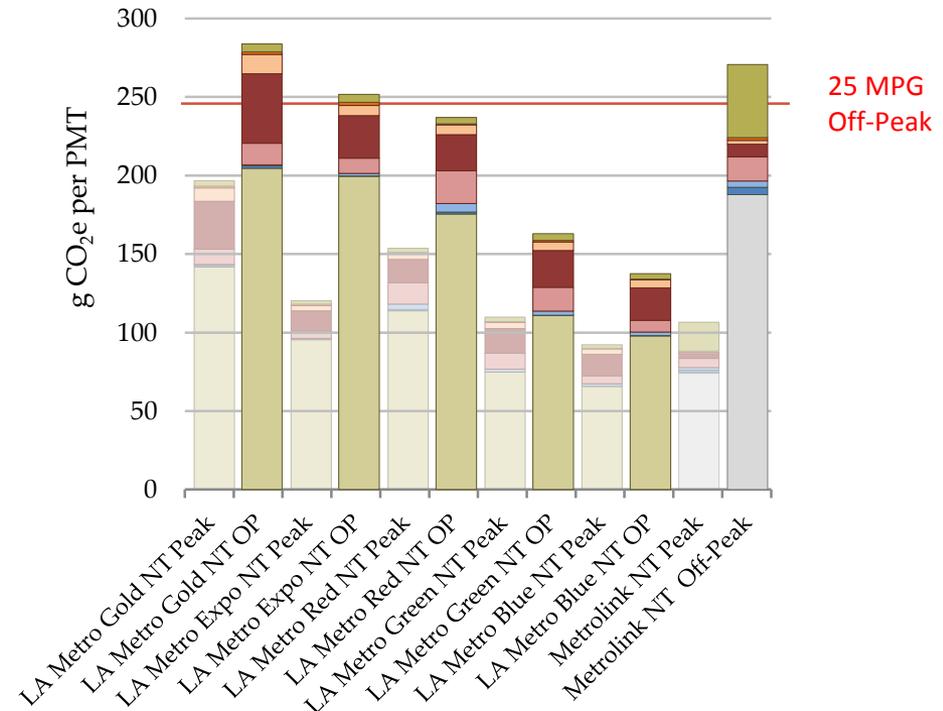
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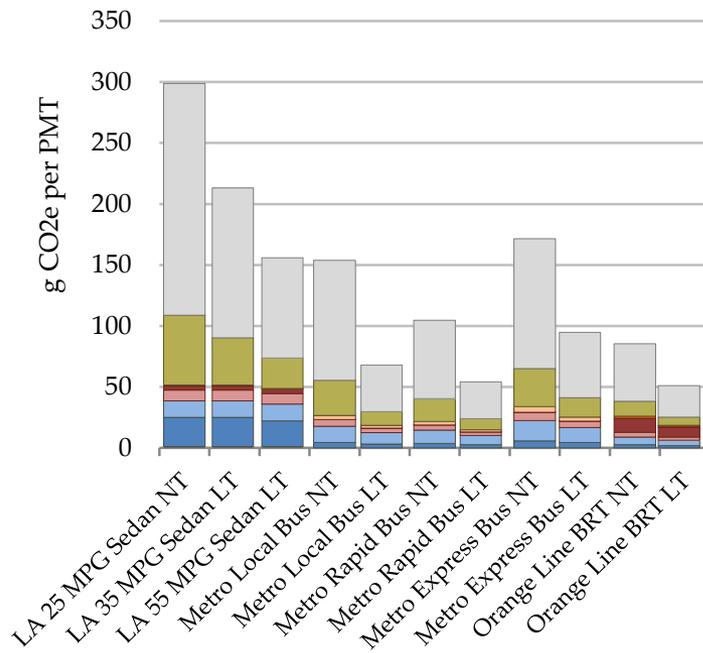


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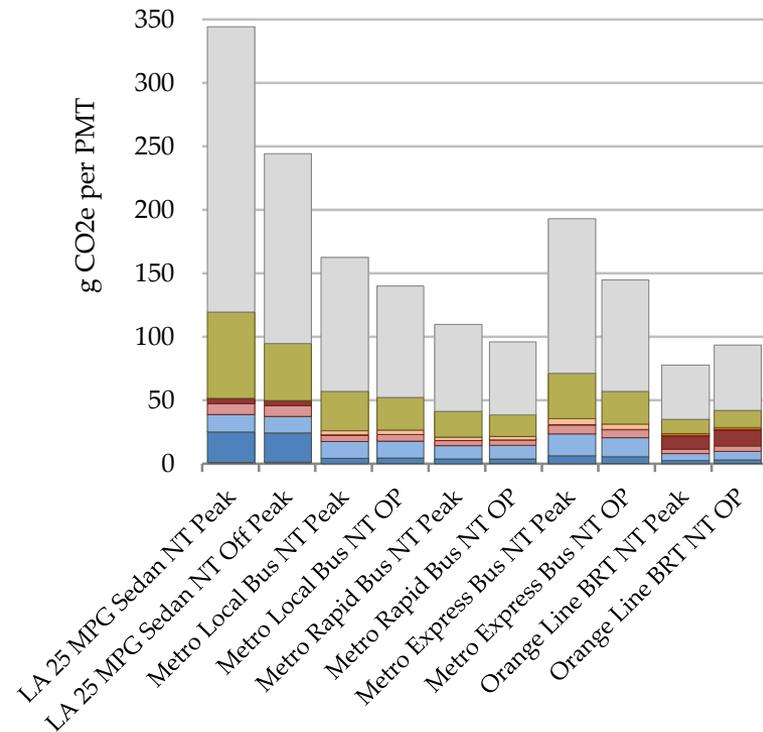
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Bus GHG Emissions per PMT

Near Term vs. Long Term



Peak vs. Off-Peak

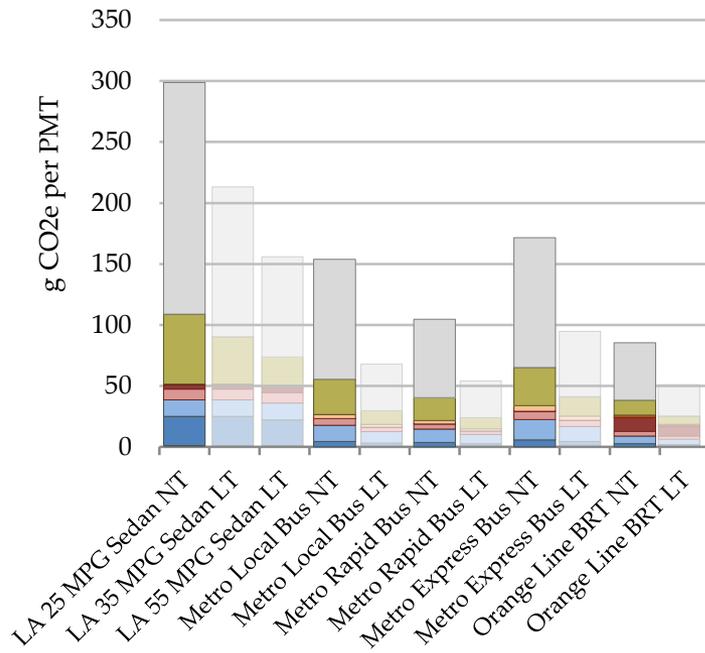


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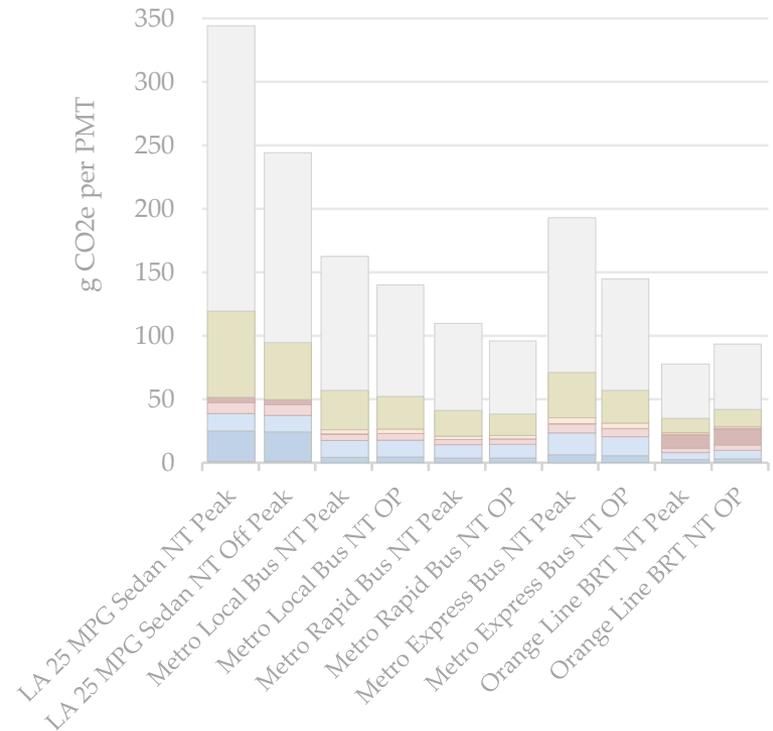
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Bus GHG Emissions per PMT

Near Term vs. Long Term



Peak vs. Off-Peak

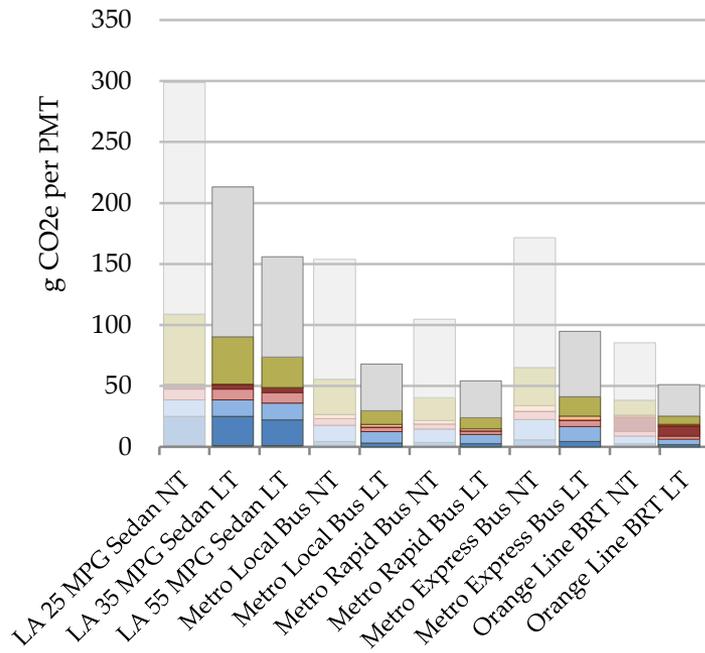


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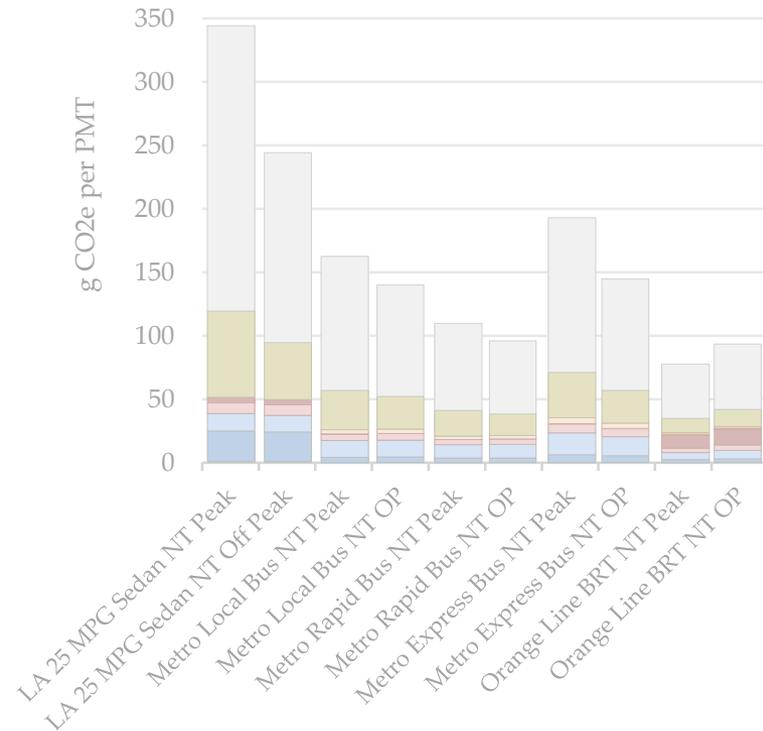
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Near Term vs. Long Term



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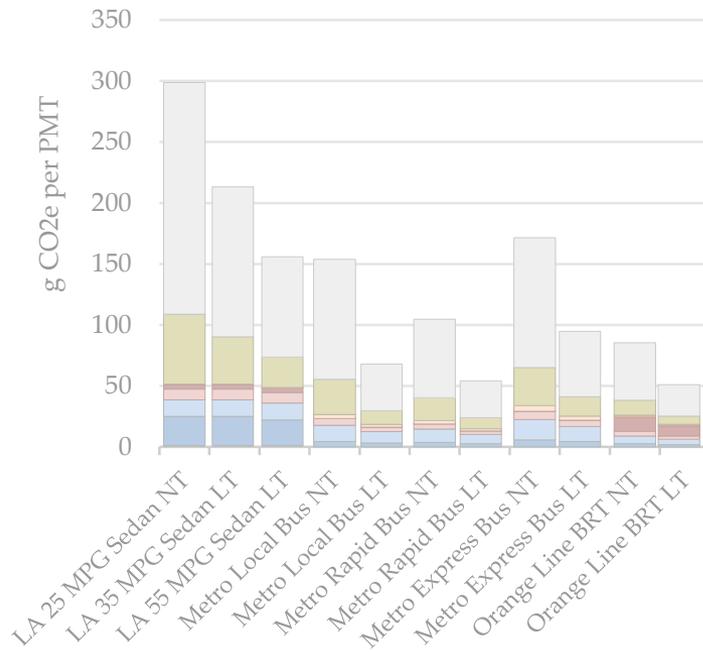


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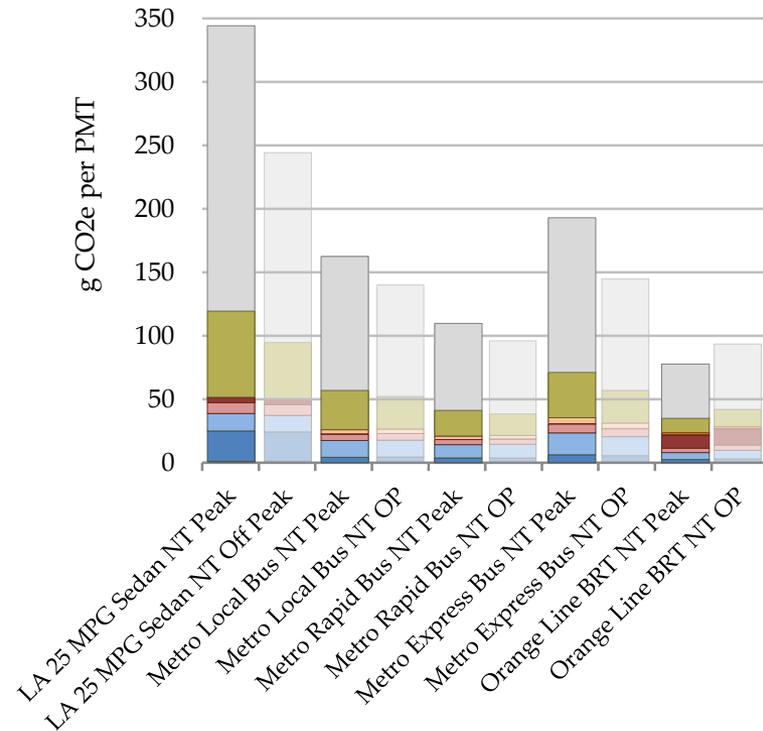
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Bus GHG Emissions per PMT

Near Term vs. Long Term



Peak vs. Off-Peak

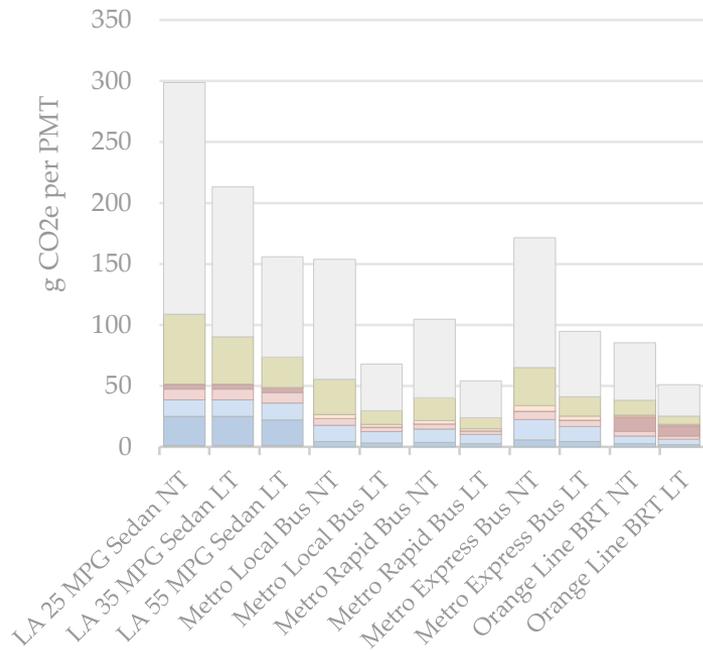


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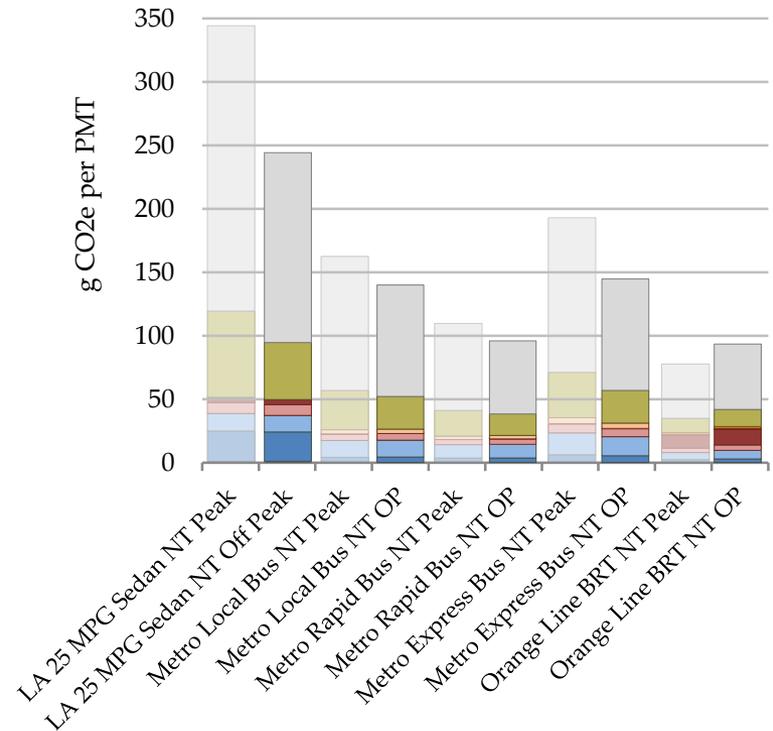
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Near Term vs. Long Term



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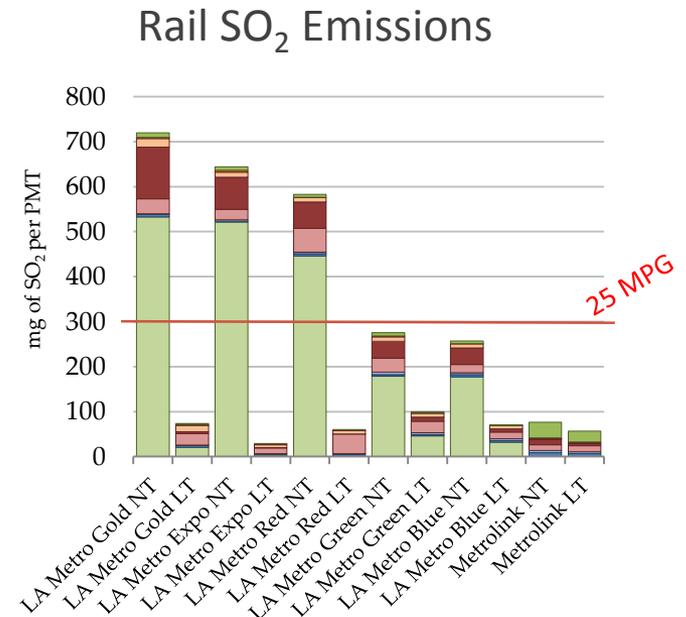


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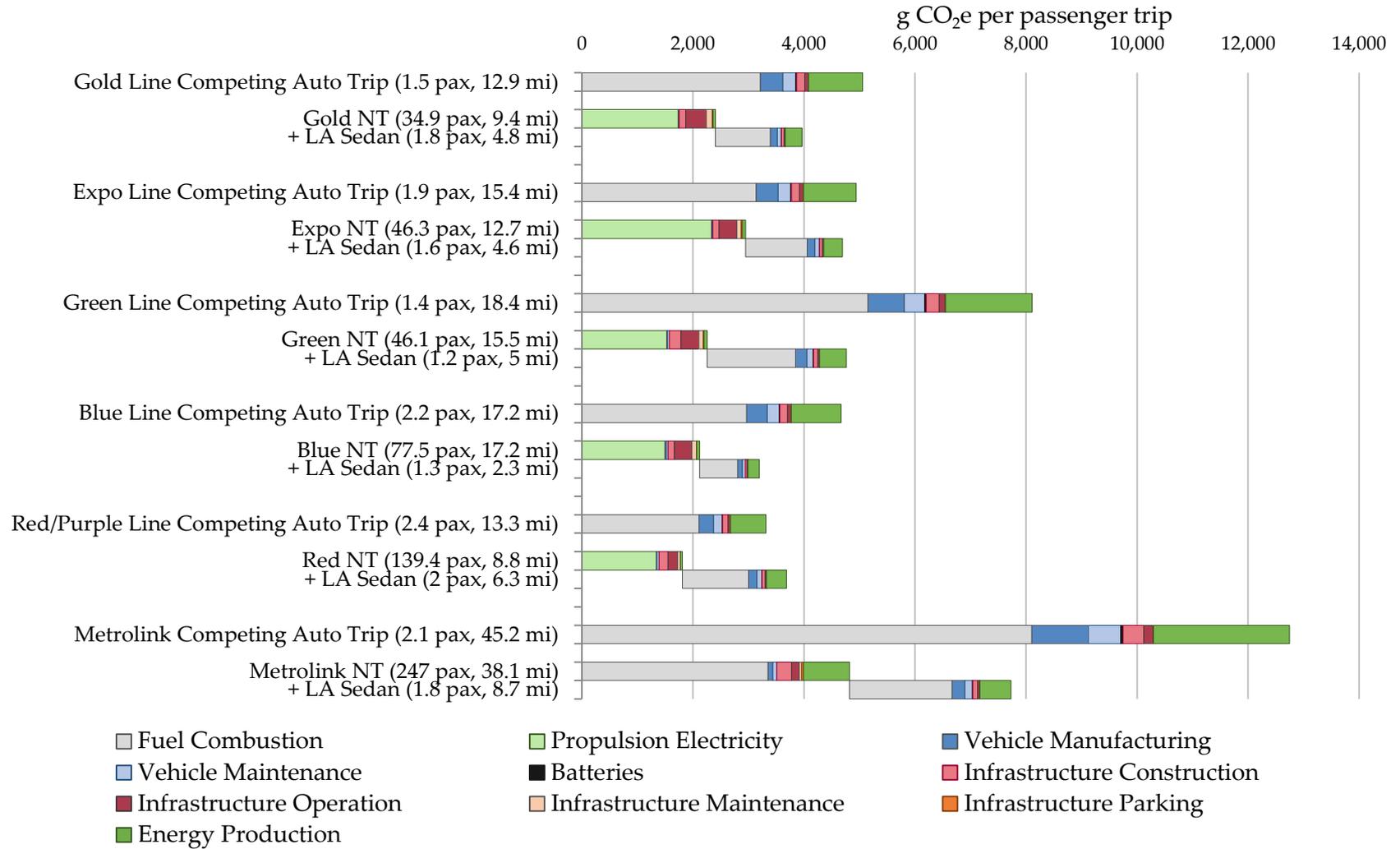
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Summary of Impacts per PMT

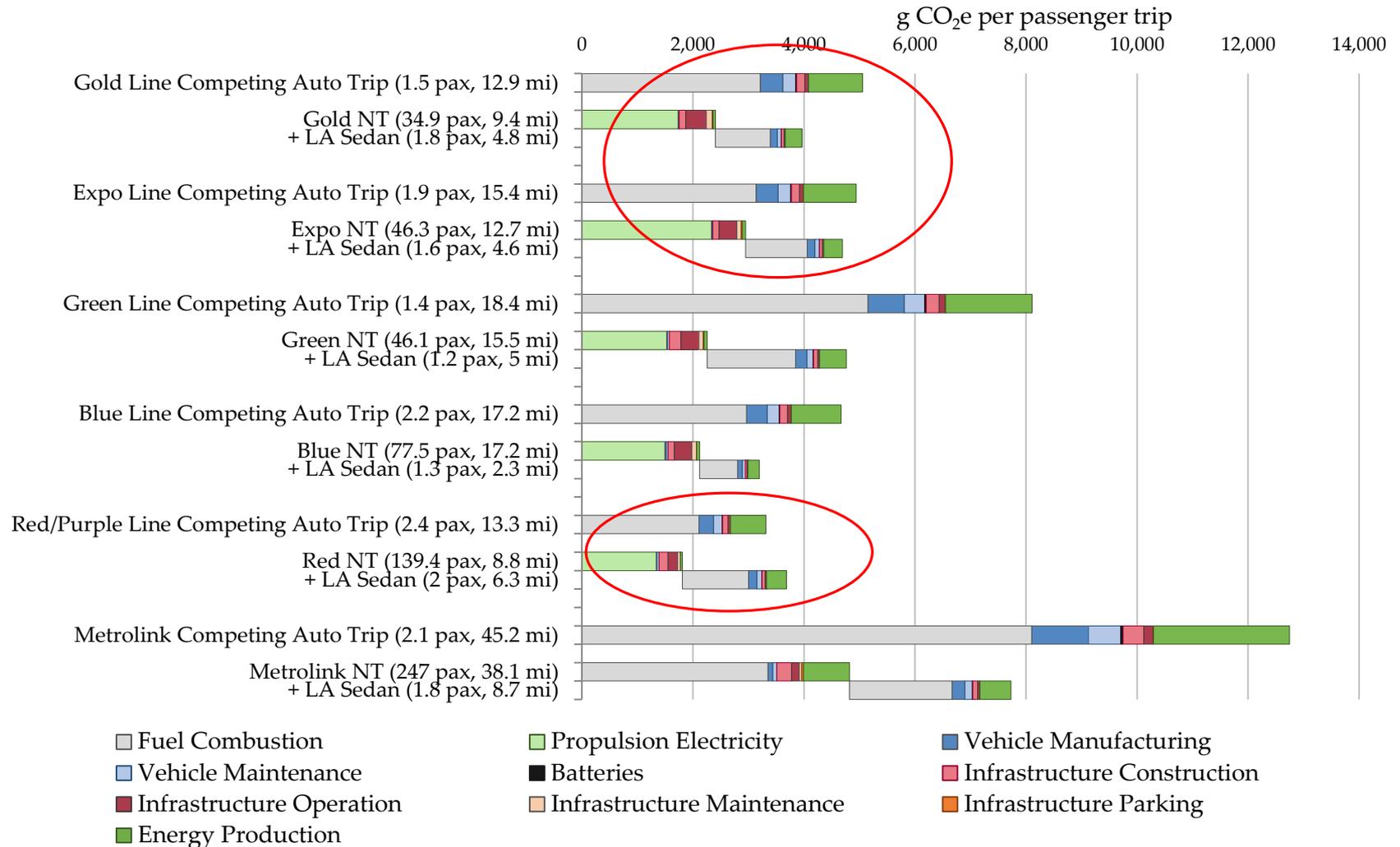
- Energy production, generation, and combustion is largest contributing factor to GHG and CAP emissions.
- Other impacts are largely occur in infrastructure construction and maintenance (cement/concrete/steel/asphalt).
- GHG and CAP emissions are lower than an average occupancy auto per PMT with some exceptions (off-peak rail).
- Auto is nearest with transit emissions during off-peak.



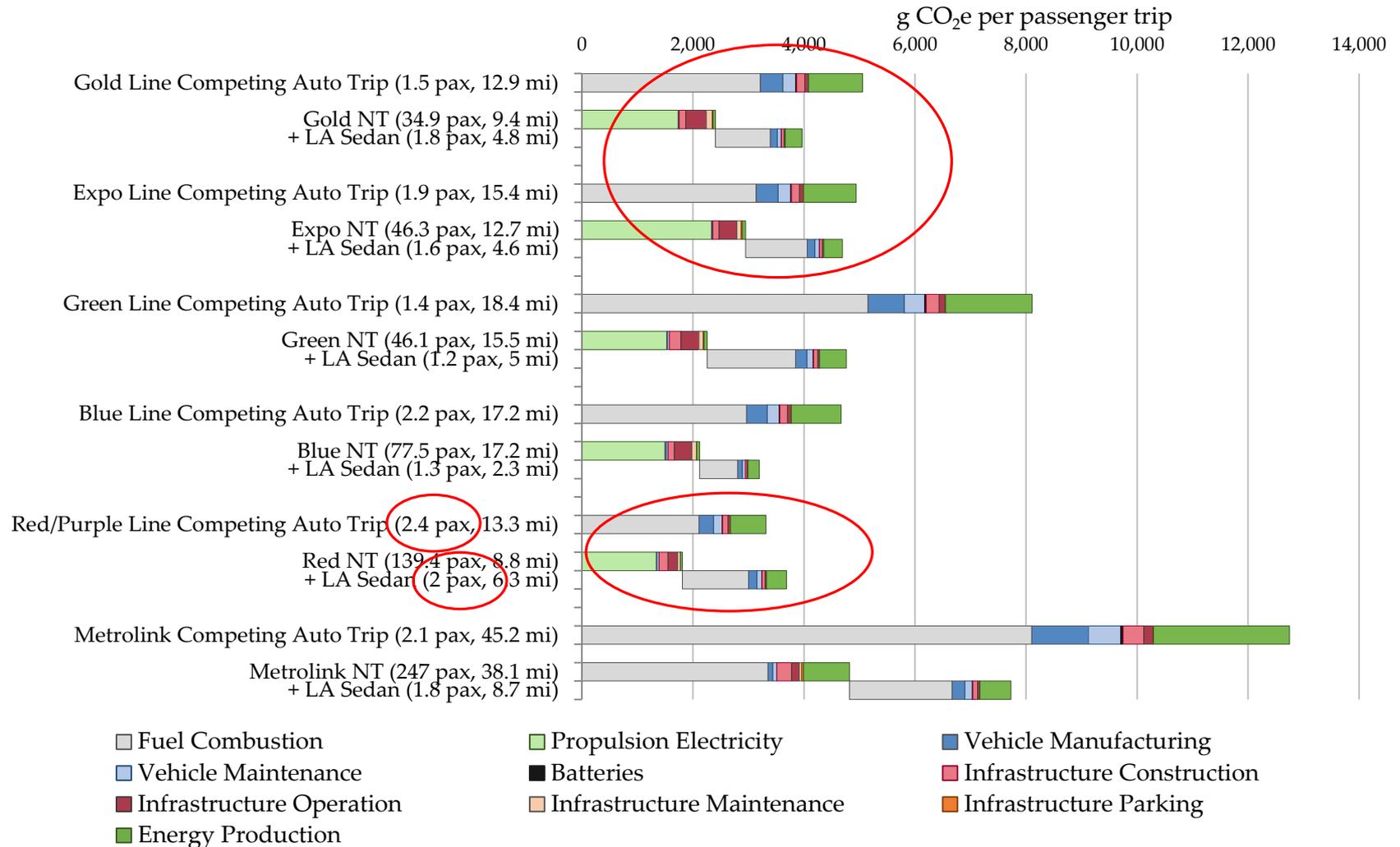
Rail + Auto First-last Mile (GHG, NT, Average)



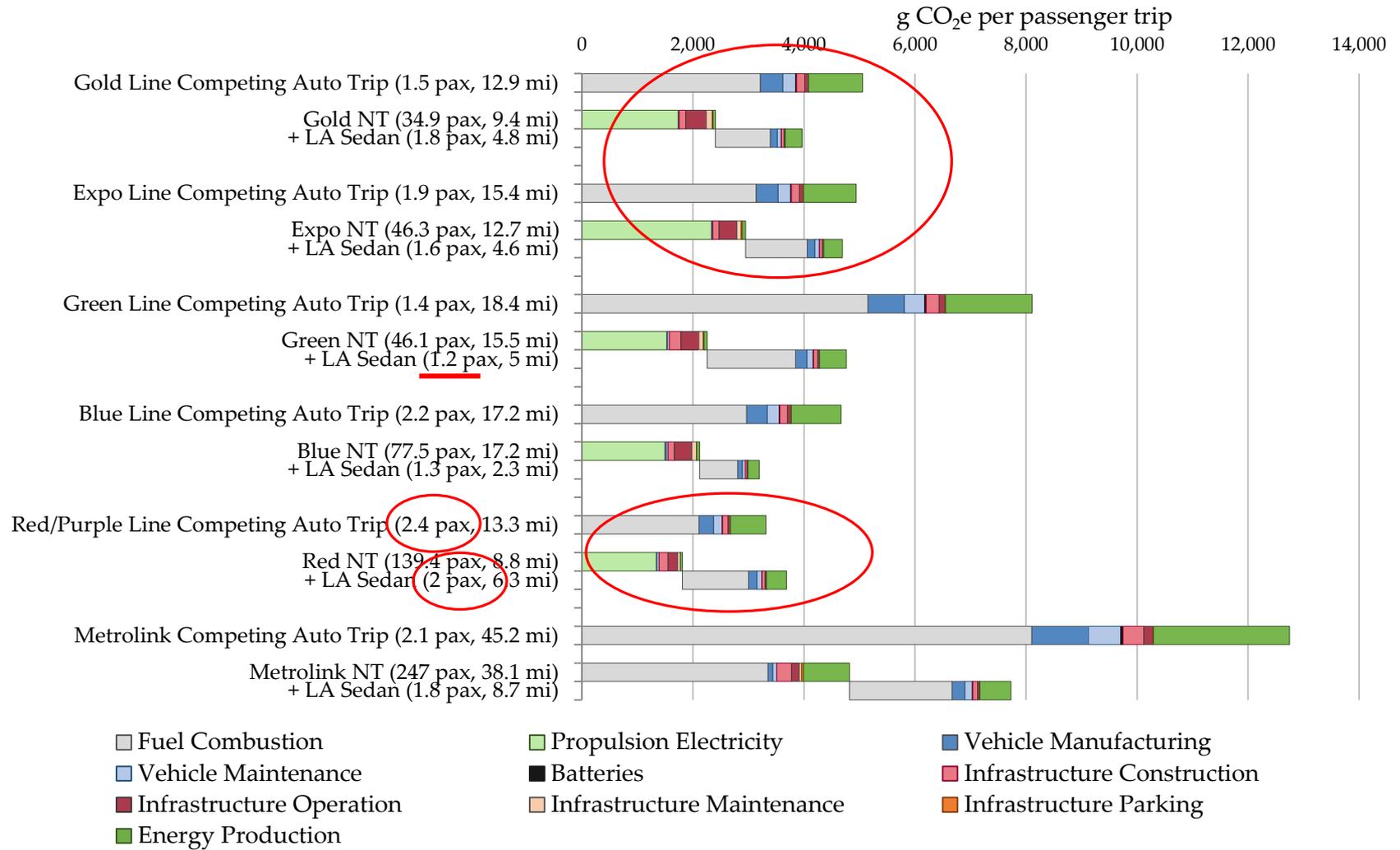
Rail + Auto First-last Mile (GHG, NT, Average)



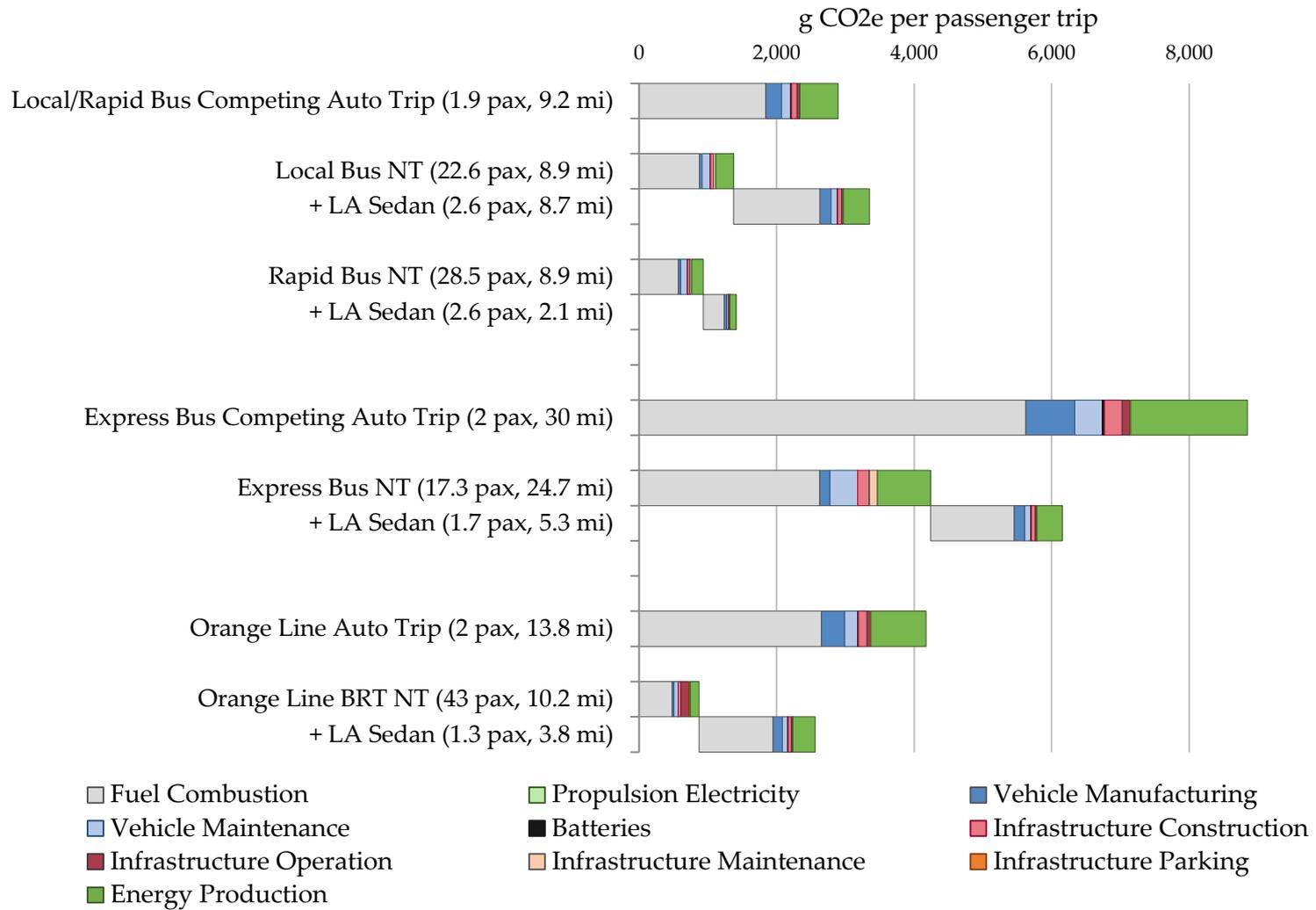
Rail + Auto First-last Mile (GHG, NT, Average)



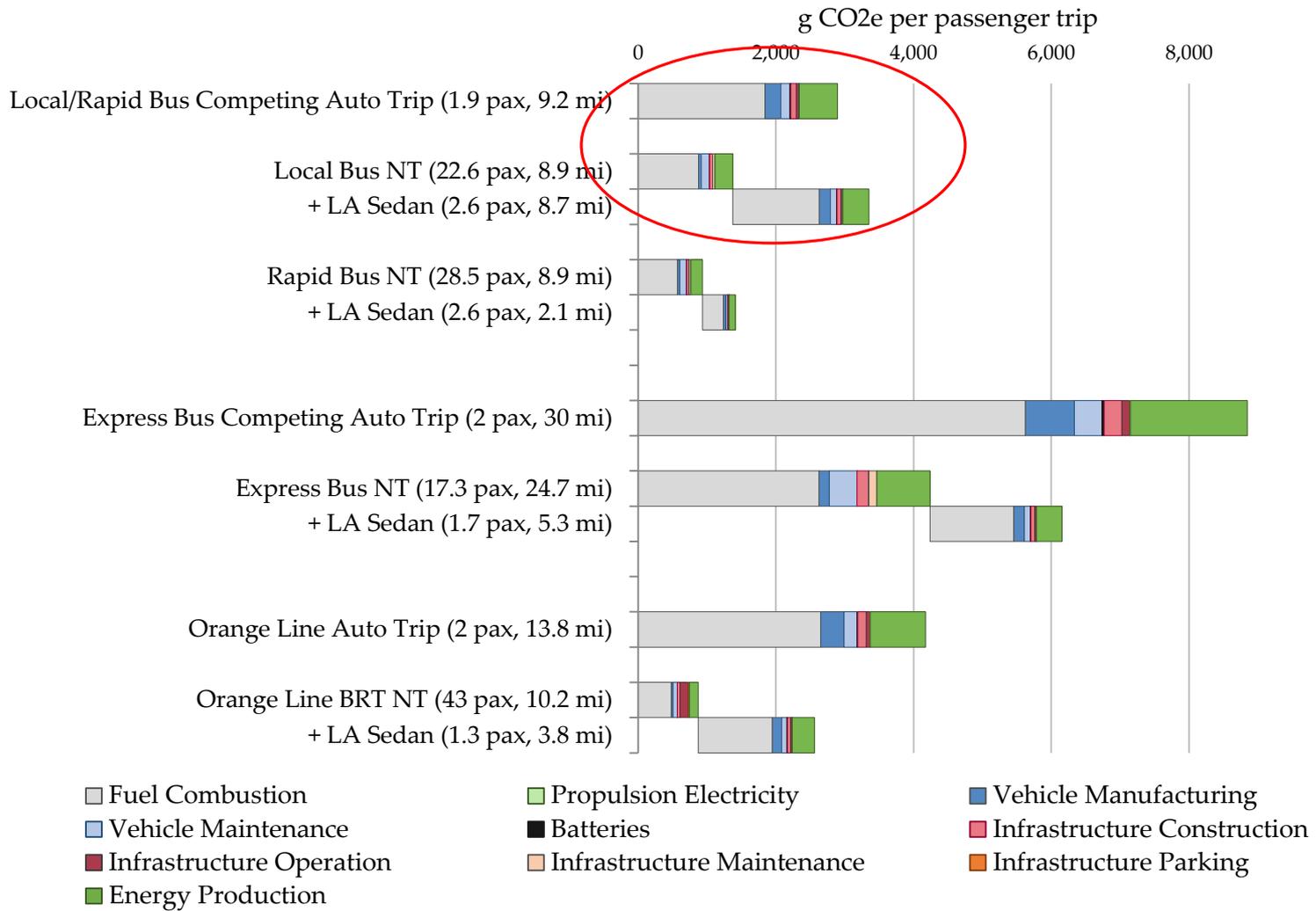
Rail + Auto First-last Mile (GHG, NT, Average)



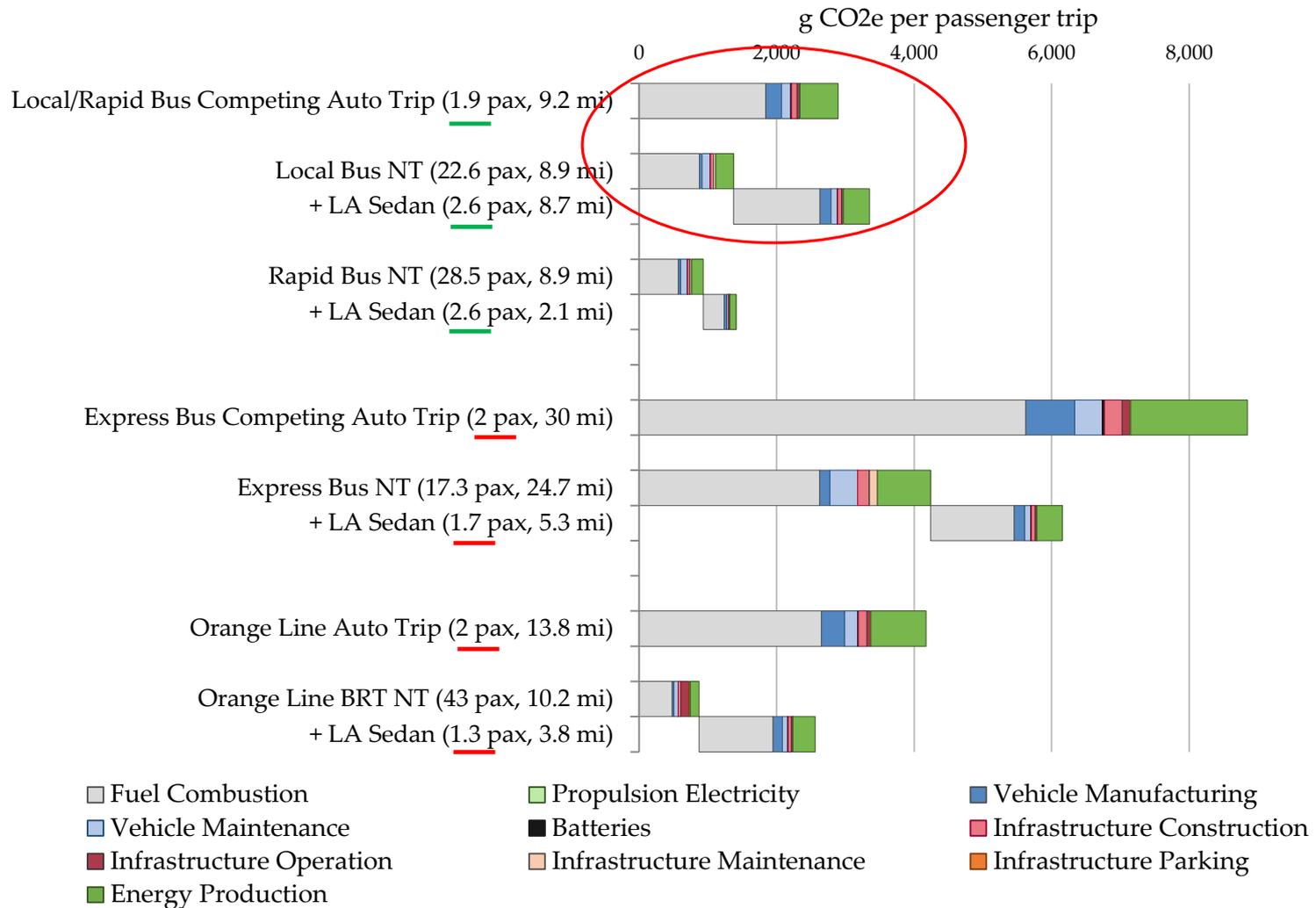
Bus + Auto First-last Mile (GHG, NT, Average)



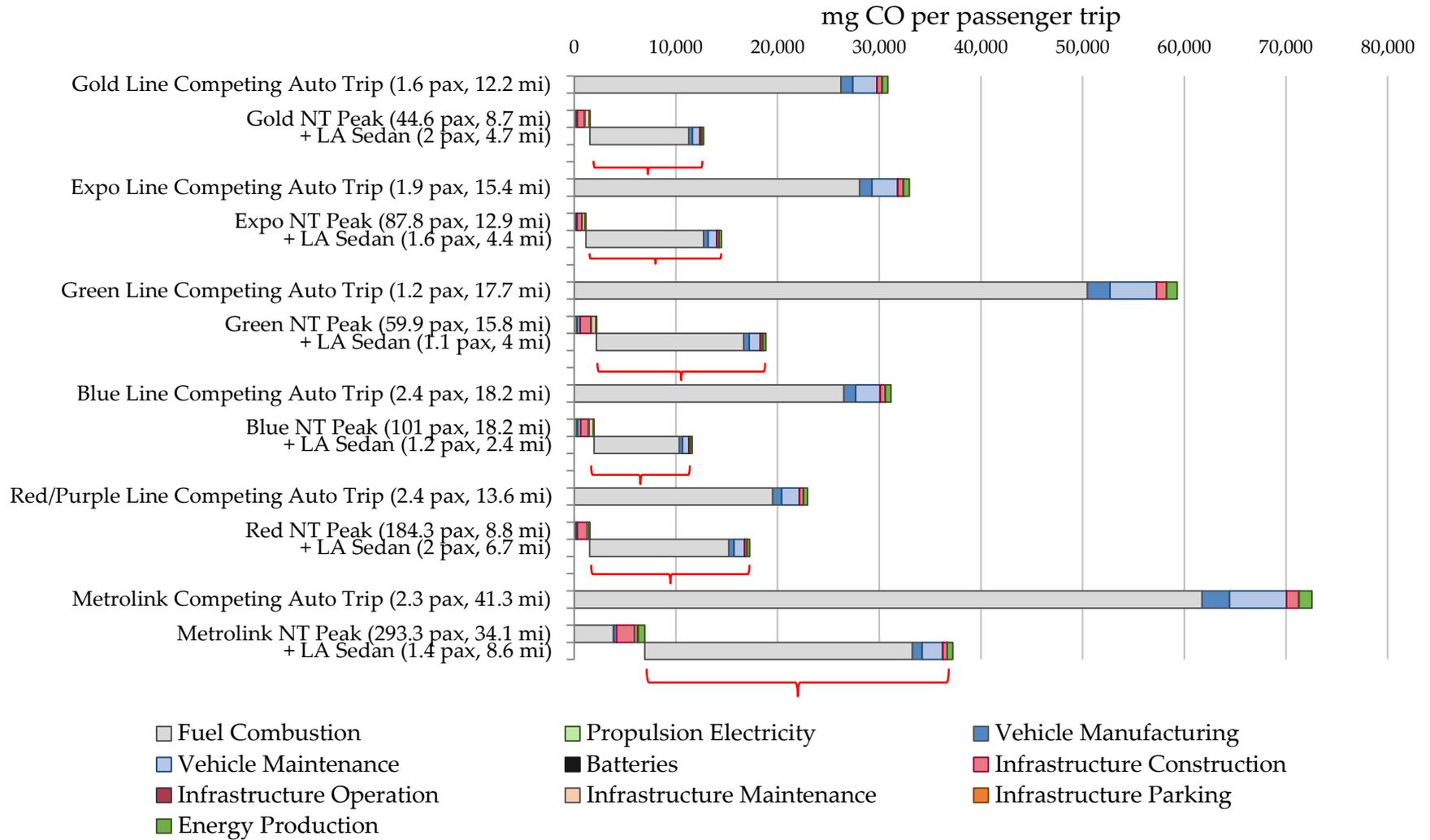
Bus + Auto First-last Mile (GHG, NT, Average)



Bus + Auto First-last Mile (GHG, NT, Average)



Rail + Auto First-last Mile (CO, NT, Peak)



Discussion of First-Last Mile Impacts

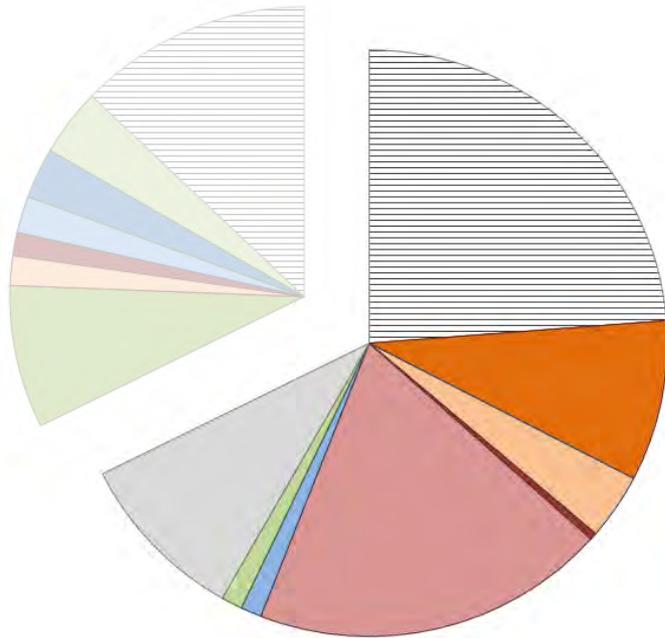
- In some cases, multimodal transit emissions may be greater than a competing auto trip.
- Net environmental impacts of multimodal transit lower than unimodal auto.
- Decarbonization of the electric grid will play a major role in reducing Metro Rail emissions.
- Most Metro rail emissions occur where energy generation is occurring (e.g. over half of the energy LADWP provides is generated out of state).
- Bus, auto, and commuter rail emissions occur largely in LA.

Quantifying Impacts

- Auto first-last mile trips can increase total trip emissions by as much as 12 times.
- In total transit system impacts, auto first-last mile accounts for:
 - 6%-18% GHG emissions
 - 13%-32% CO emissions
 - 12%-31% VOC emissions
- In Metro rail system, **60%-75%** of CO and VOC emissions from auto first-last mile trips

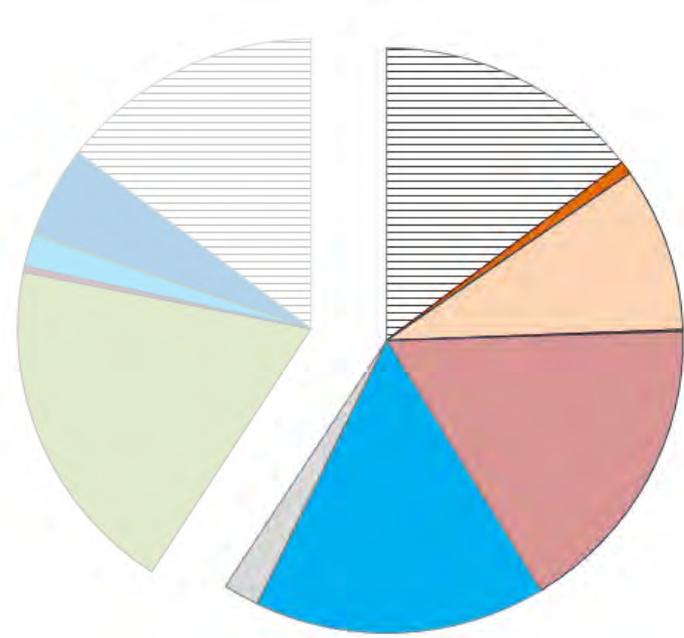
Long Term F/L Impact Potential

Rail Long Term Smog Impact Potential
Remote vs. Local



Assumes 12 auto PMT per 100 rail PMT

Bus Long Term Respiratory Impact Potential
Remote vs. Local



Assumes 8 auto PMT per 100 bus PMT

- ☐ F/L Mile Auto
- Fuel Production
- Infrastructure Parking
- Infrastructure Maintenance
- Infrastructure Operation
- Infrastructure Construction
- Vehicle Maintenance
- Vehicle Manufacturing
- Propulsion Electricity
- Fuel Combustion

Scenarios for Reductions

- Auto access and egress to transit is often lower occupancy than competing auto trips.
- Possible strategies could be implemented:
 - Adjust parking availability and pricing
 - Promote and incentivizing carpooling/ridesharing
 - Increase non-motorized transit accessibility such as increased bike access or walkability.
 - Expanding transit access and/or further incentives to use multimodal transit trips without auto.

Research Questions Revisited

1. What effects do auto access and egress have on greenhouse gas (GHG) emissions and criteria air pollutants (CAP) in multimodal transit trips?

First-last mile auto trips will increase total multimodal trip GHG and CAP emissions significantly in many cases, especially increasing local impacts.

2. Are multimodal transit trips with auto access or egress still effective in reducing environmental impacts?

It depends on many factors. With single occupancy auto access and egress it will increase emissions. High first-last mile auto occupancies would reduce impacts over unimodal auto trips.

3. How do multimodal transit emissions with auto access or egress compare to a competing auto trip?

There are many cases where multimodal transit emissions are similar to a competing auto trip. Current off-peak F/L travel with the Metro Gold, Expo, and Red lines are most similar to auto.

Questions?



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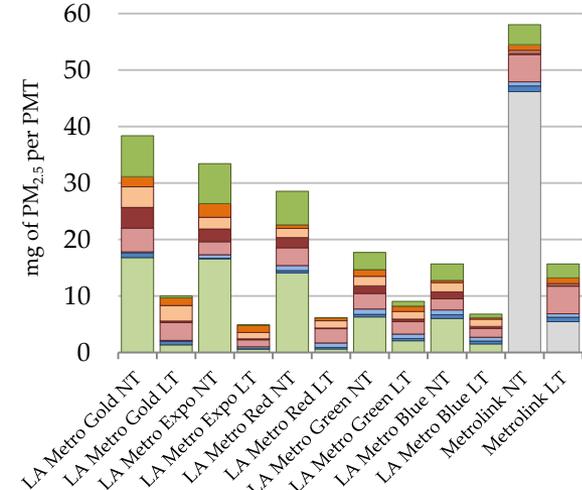
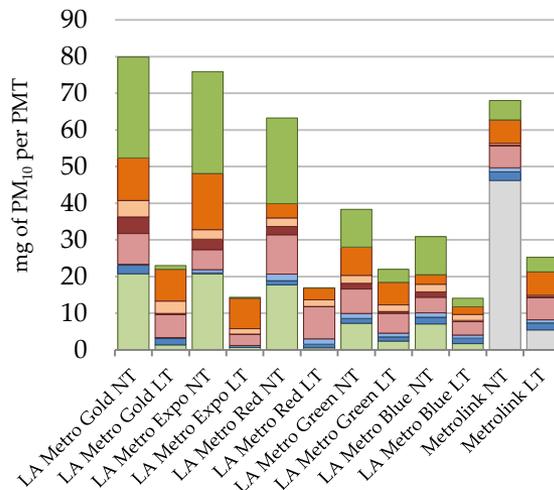
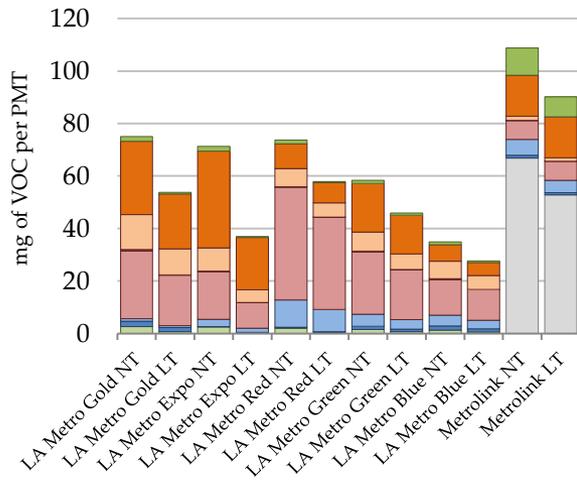
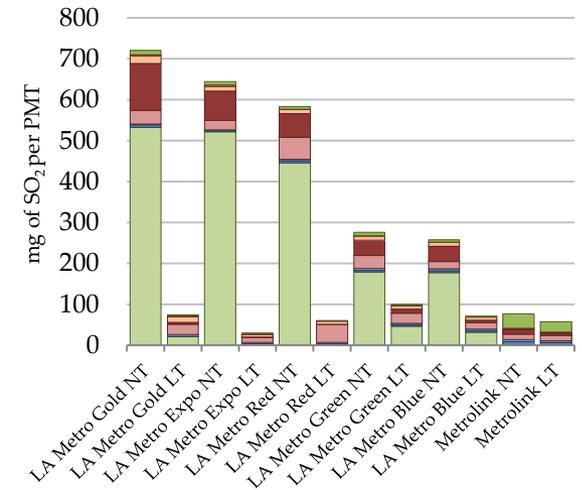
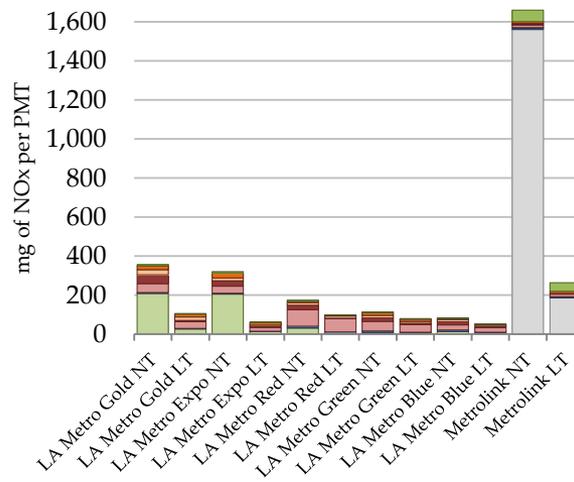
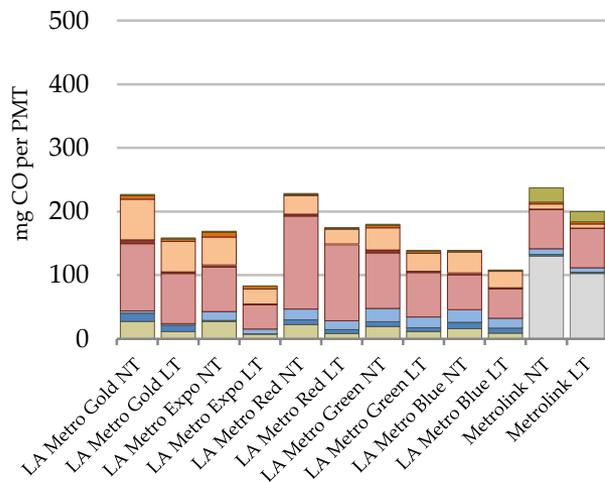


chrishoehne

System Boundary

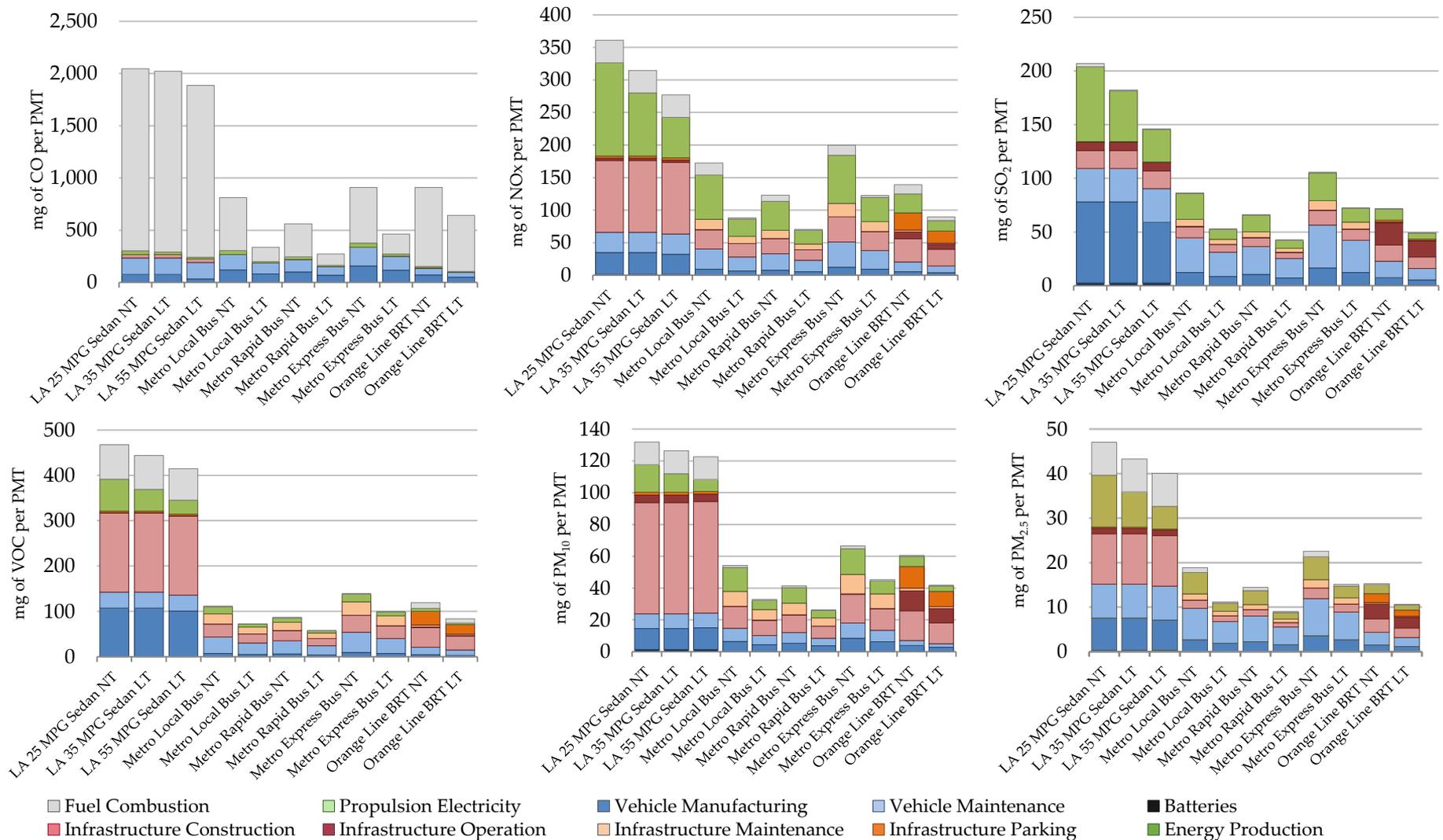
Life Cycle Grouping	Automobiles/Buses	Rail
Vehicle		
Manufacturing	<ul style="list-style-type: none"> ▪ Vehicle Manufacturing ▪ Battery Manufacturing ▪ Transport to Point of Sale 	<ul style="list-style-type: none"> ▪ Train ▪ Transport to Point of Sale
Operation	<ul style="list-style-type: none"> ▪ Propulsion ▪ Idling 	<ul style="list-style-type: none"> ▪ Propulsion ▪ Idling
Maintenance	<ul style="list-style-type: none"> ▪ Typical Maintenance ▪ Tire Replacement ▪ Battery Replacement 	<ul style="list-style-type: none"> ▪ Typical Train Maintenance ▪ Train Cleaning ▪ Flooring Replacement
Infrastructure		
Construction	<ul style="list-style-type: none"> ▪ Roadway 	<ul style="list-style-type: none"> ▪ Track ▪ Station
Operation	<ul style="list-style-type: none"> ▪ Roadway Lighting ▪ Herbicide Use 	<ul style="list-style-type: none"> ▪ Track, Station, and Parking Lighting ▪ Herbicide Use ▪ Train Control ▪ Miscellaneous (Escalators, Equipment)
Maintenance	<ul style="list-style-type: none"> ▪ Roadway Maintenance 	<ul style="list-style-type: none"> ▪ Track and Station Maintenance
Parking	<ul style="list-style-type: none"> ▪ Curbside Parking 	<ul style="list-style-type: none"> ▪ Dedicated Parking
Energy Production		
Extraction, Processing, & Distribution	<ul style="list-style-type: none"> ▪ Gasoline/Diesel/Natural Gas Extraction, Processing, & Distribution 	<ul style="list-style-type: none"> ▪ Raw Fuel Extraction and Processing, Electricity Generation, Transmission & Distribution

Near Term Rail CAP Emissions Per Pax-Mile

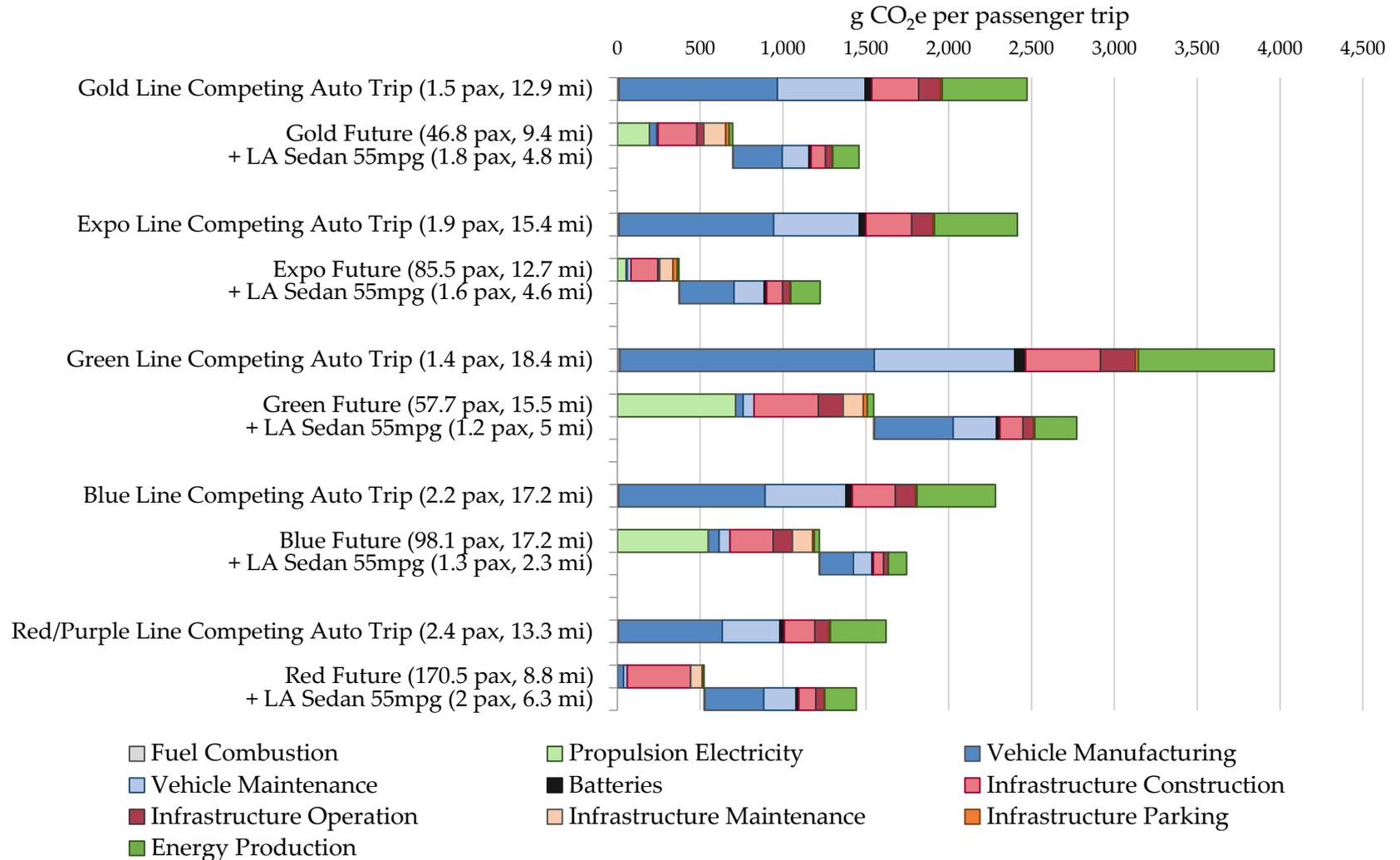


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Near Term On-Road CAP Emissions Per Pax-Mile



Rail + Auto First-last Mile (SO₂, LT, Average)



What is First-Last Mile?

- First-last mile is short for the first and last segments (access and egress) of a multimodal trip.
- Walking, biking, automobile, carpool, etc.



Source: Los Angeles Metro First Last Mile Strategic Plan

What is Life-Cycle Assessment?

- Electric supply technologies
- Agriculture processes
- Industrial processes
- *Civil (e.g. transportation) systems*

