

First-last mile environmental life-cycle assessment of multimodal transit in Los Angeles

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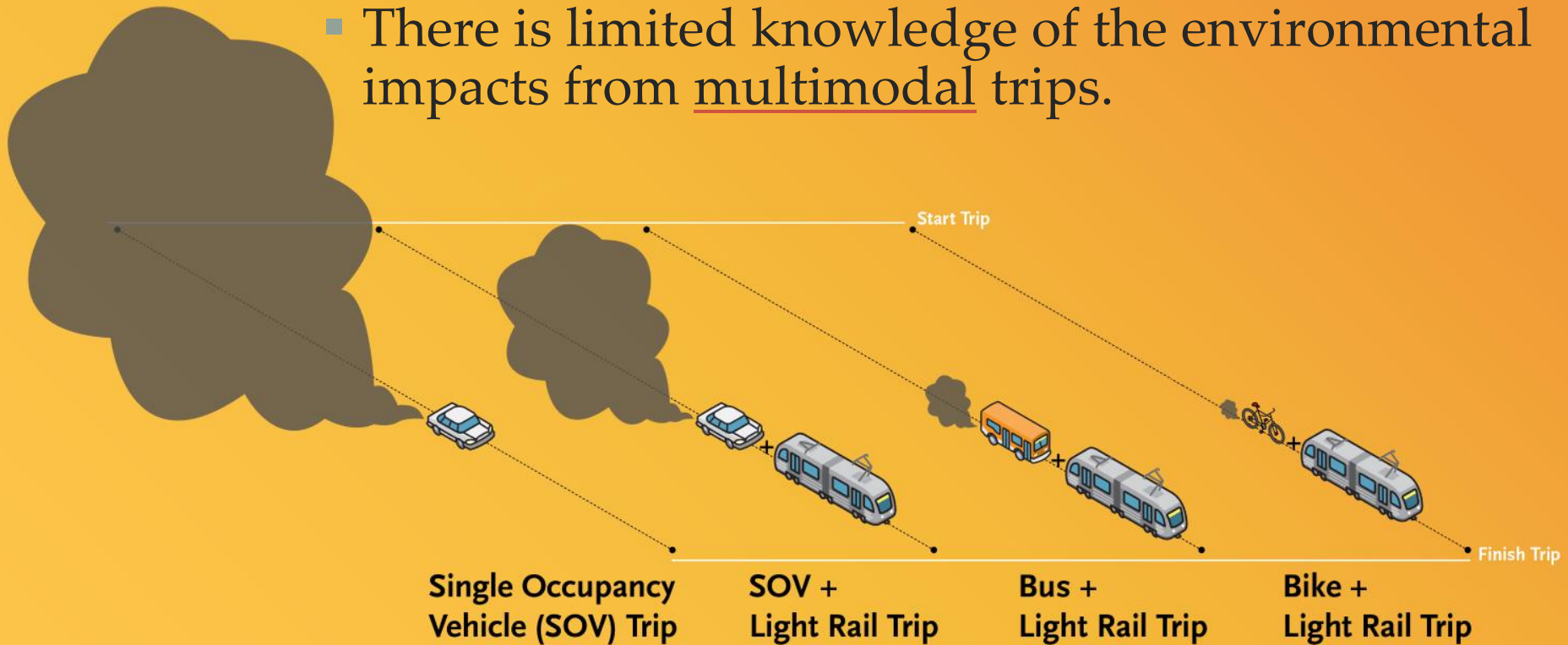
Outline

- Project motivation
- Project overview and scope
- Project methodology & data
- Life cycle impacts (per passenger mile)
- Multimodal impacts (per passenger trip)
- Reducing 10% of system GHG impacts



Motivation in transportation

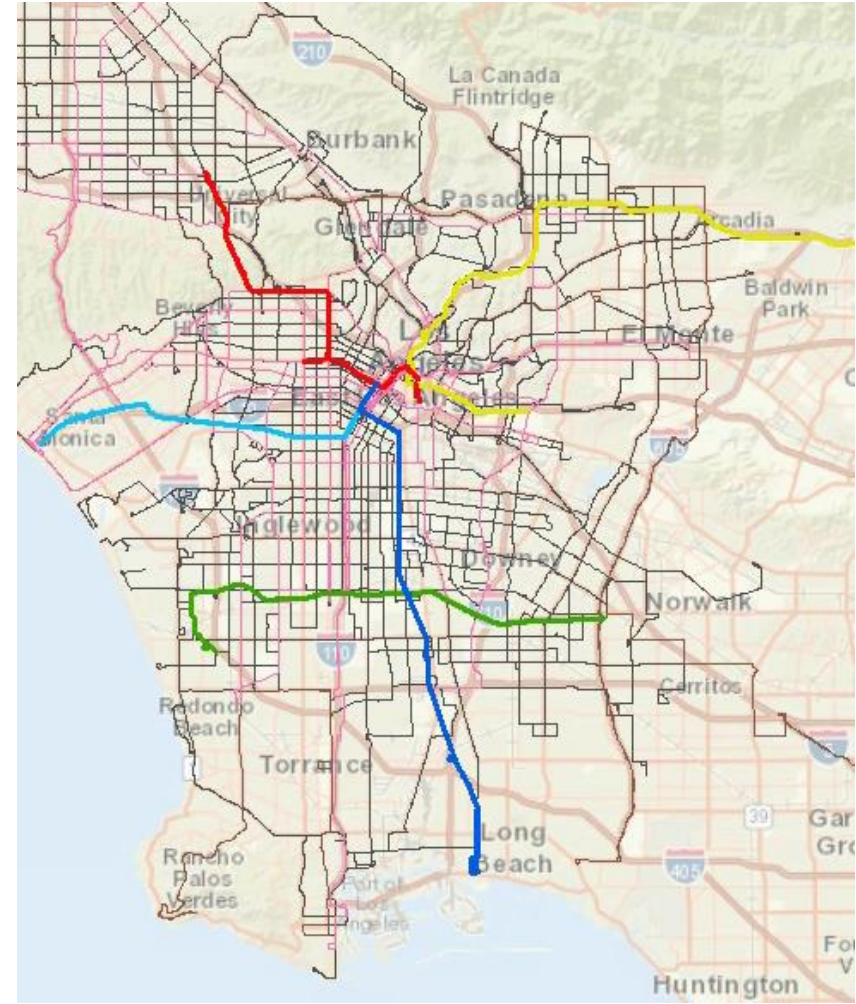
- There is a strong understanding of the environmental impacts from unimodal trips.
- There is limited knowledge of the environmental impacts from multimodal trips.



- Very limited knowledge of impacts from automobile access and egress with transit.

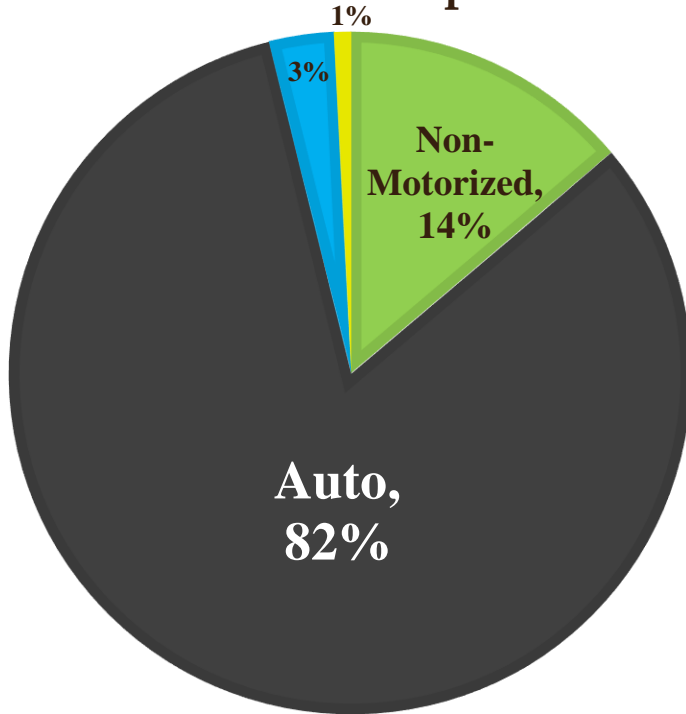
Project Overview

- Assess impacts generated from 10 LA transit systems and LA automobiles.
- Transit systems included:
 - Metro Light Rail Transit (LRT, 4 lines)
 - Metro Heavy Rail Transit (HRT, 1 line)
 - Commuter Rail Transit (CRT, 1 line)
 - Metro Local Bus
 - Metro Rapid Bus
 - Metro Express Bus
 - Bus Rapid Transit (BRT, 1 line)
- LA Auto:
 - 25 MPG sedan



Modal Split in LA

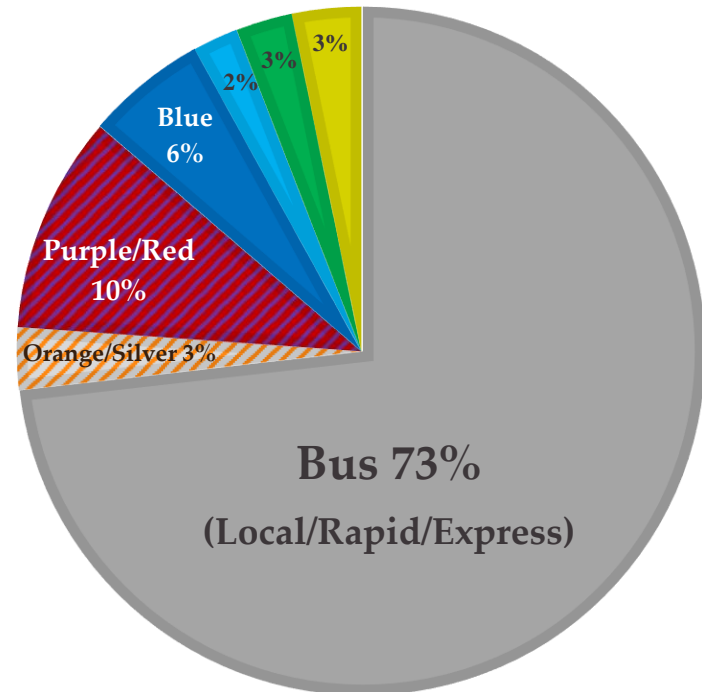
Modal Split



- Non-Motorized
- Auto
- Metro Transit
- Other

Estimate via California Household Travel Survey (Caltrans, 2013)

Transit Modal Split



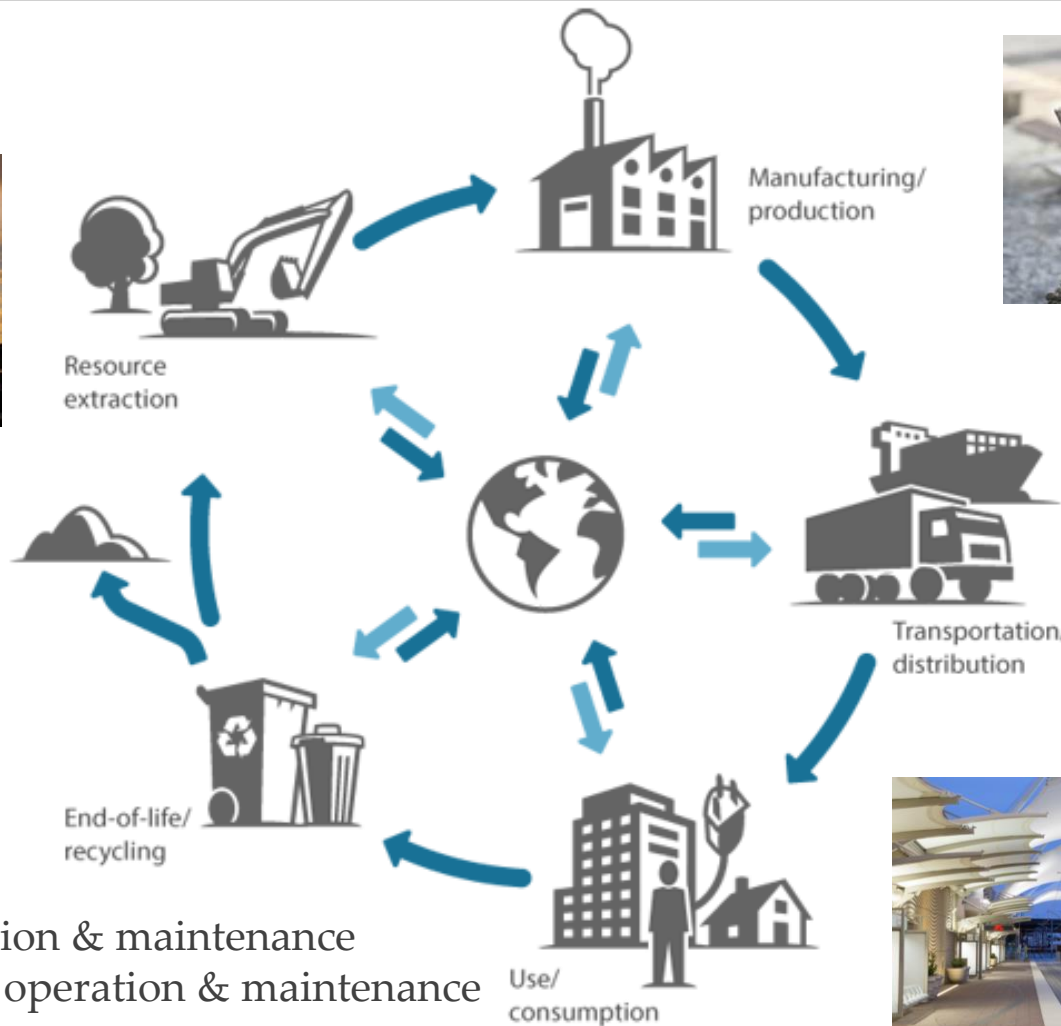
- Bus
- Blue
- Gold
- BRT
- Expo
- Heavy Rail
- Green

Estimate via LA Metro boardings (LA Metro, 2016)

Life-Cycle Assessment Scope



- Material and fuel extraction



- Vehicle manufacturing
- Infrastructure construction
- Electricity production and generation

- Vehicle operation & maintenance
- Infrastructure operation & maintenance



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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

Data & Tools

Trip data:

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



Transit operational data:

- Ridership & Operation Reports (2013 – current)
- Engineering design documents, Google Earth

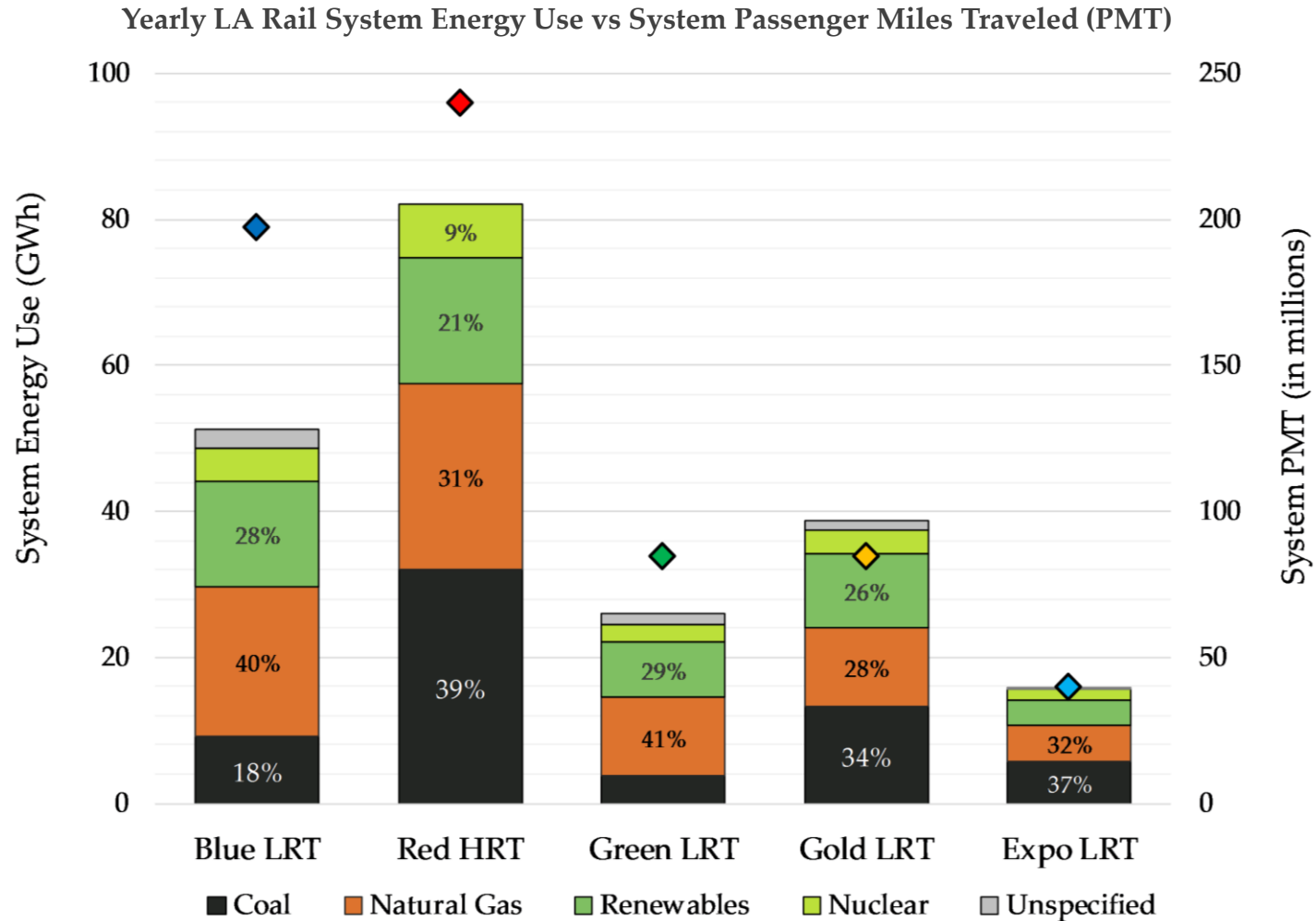


Life-cycle Modeling:

- Modeling tools including SimaPro, GREET, CiRN-LCA, and other components
- EcoInvent and EIOLCA database and empirical studies



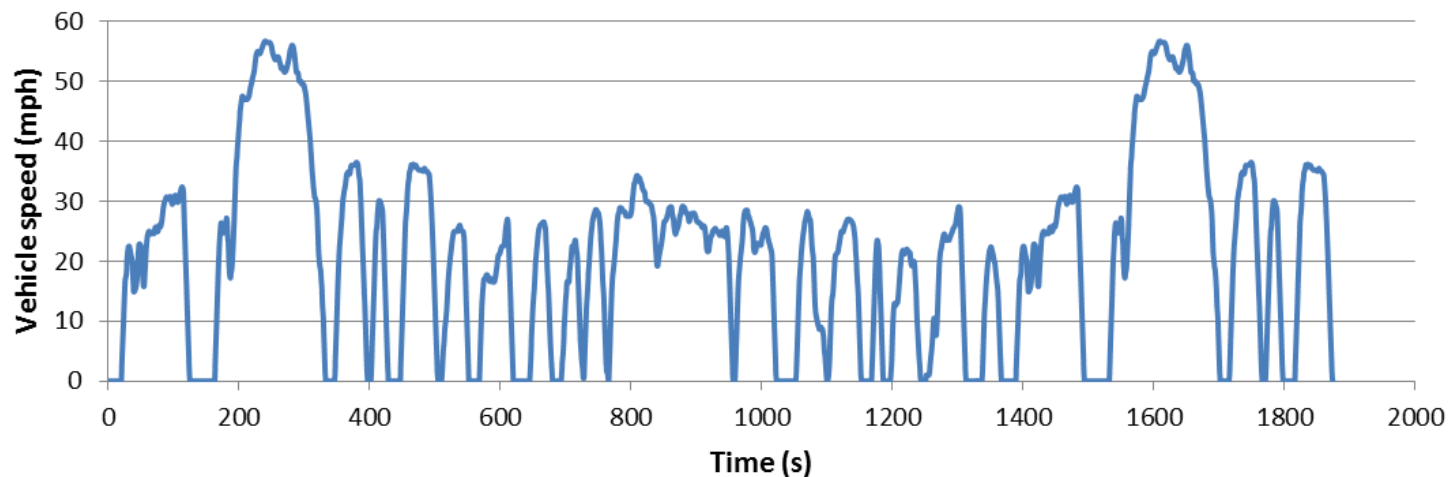
LA Metro Rail Energy Use



* Reflects 2013-2014 data

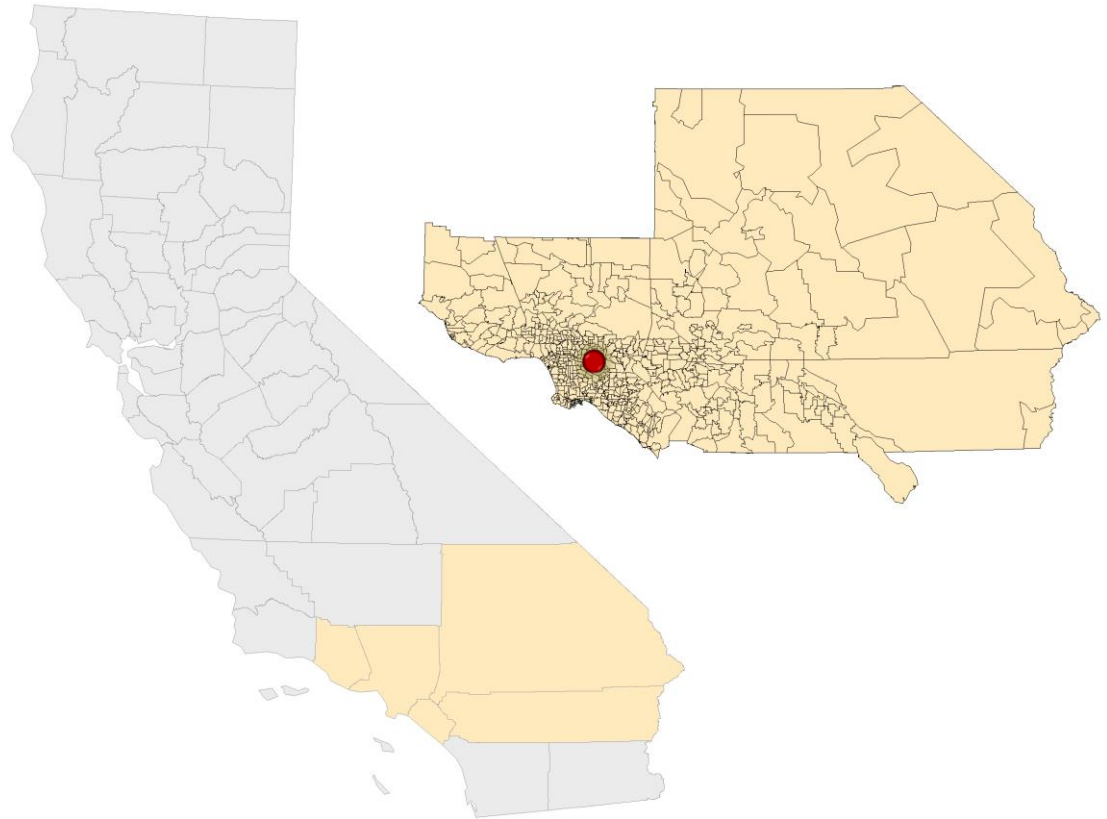
Bus & Metrolink Drive Cycles

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



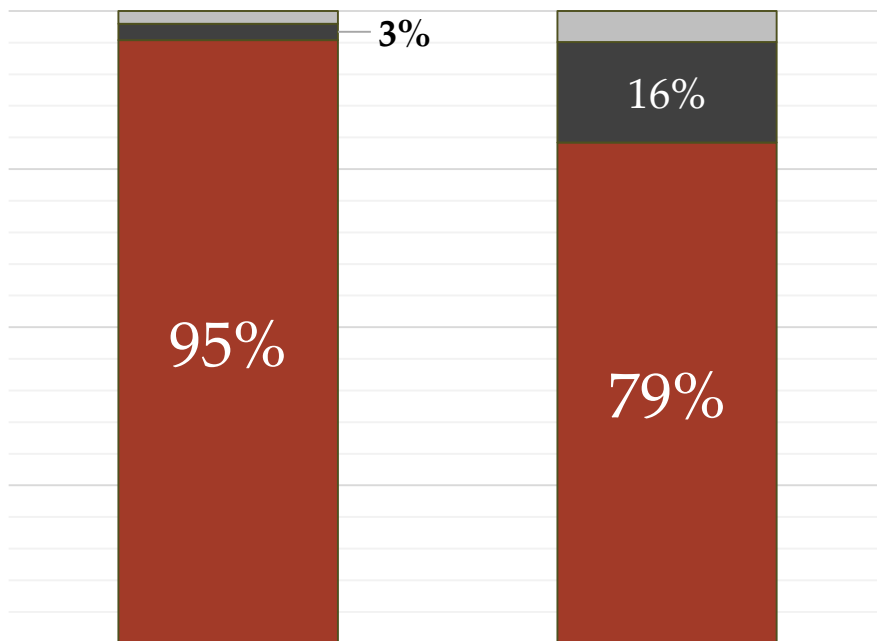
Trip Characteristics (CHTS)

- 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.



Transit Access & Egress in LA

Access & Egress Modes
(2012-13 CHTS)

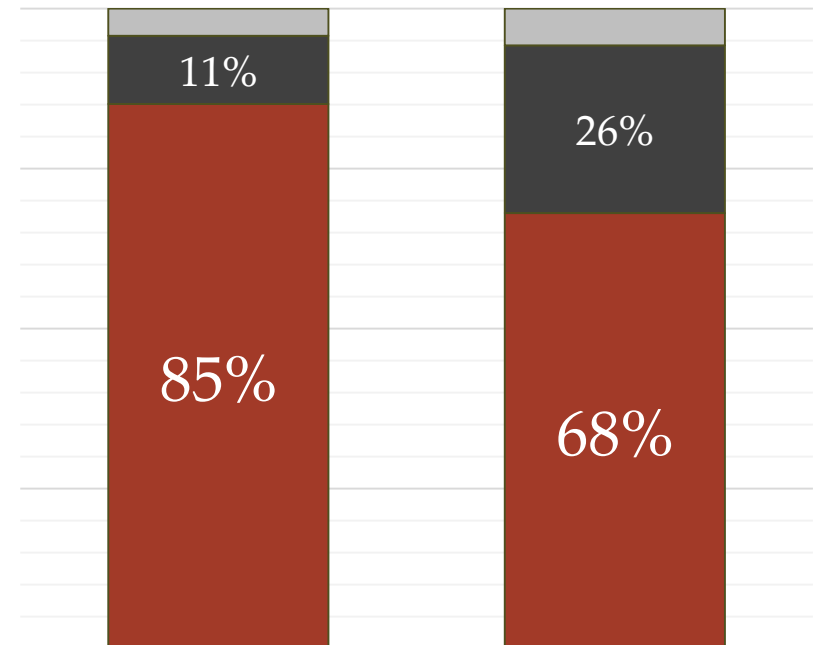


Metro Bus

Metro Rail

■ Walk/Bike ■ Auto ■ Other

Access Mode
(2012-13 Metro Surveys)



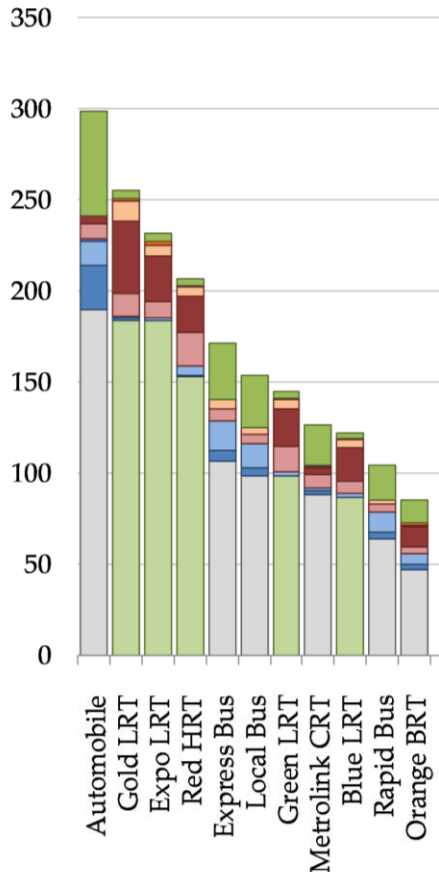
Metro Bus

Metro Rail

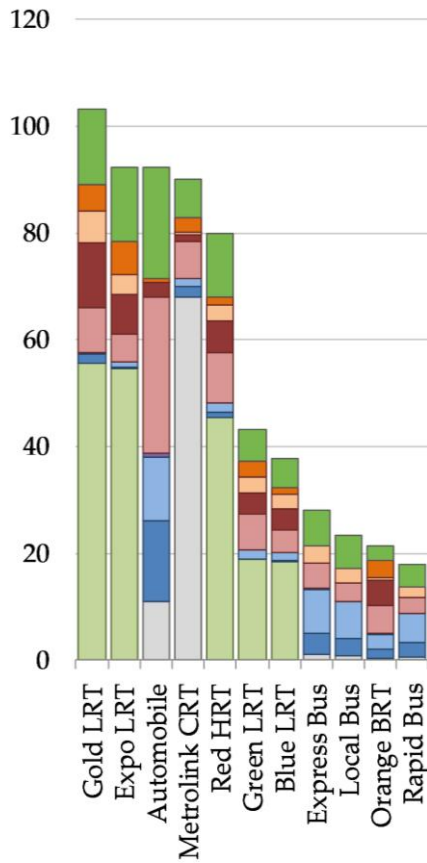
■ Walk/Bike ■ Auto ■ Other

Per Passenger-mile Impacts

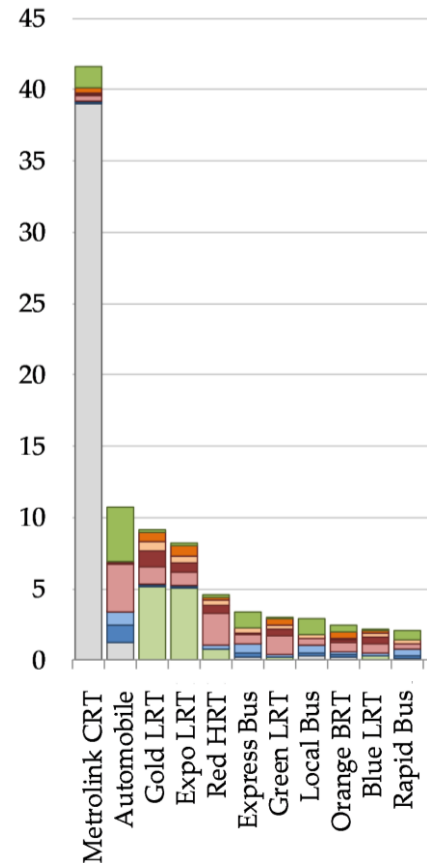
GHGs (g CO₂e/PMT)



Respiratory (mg PM_{2.5}e/PMT)



Smog (g O₃e/PMT)

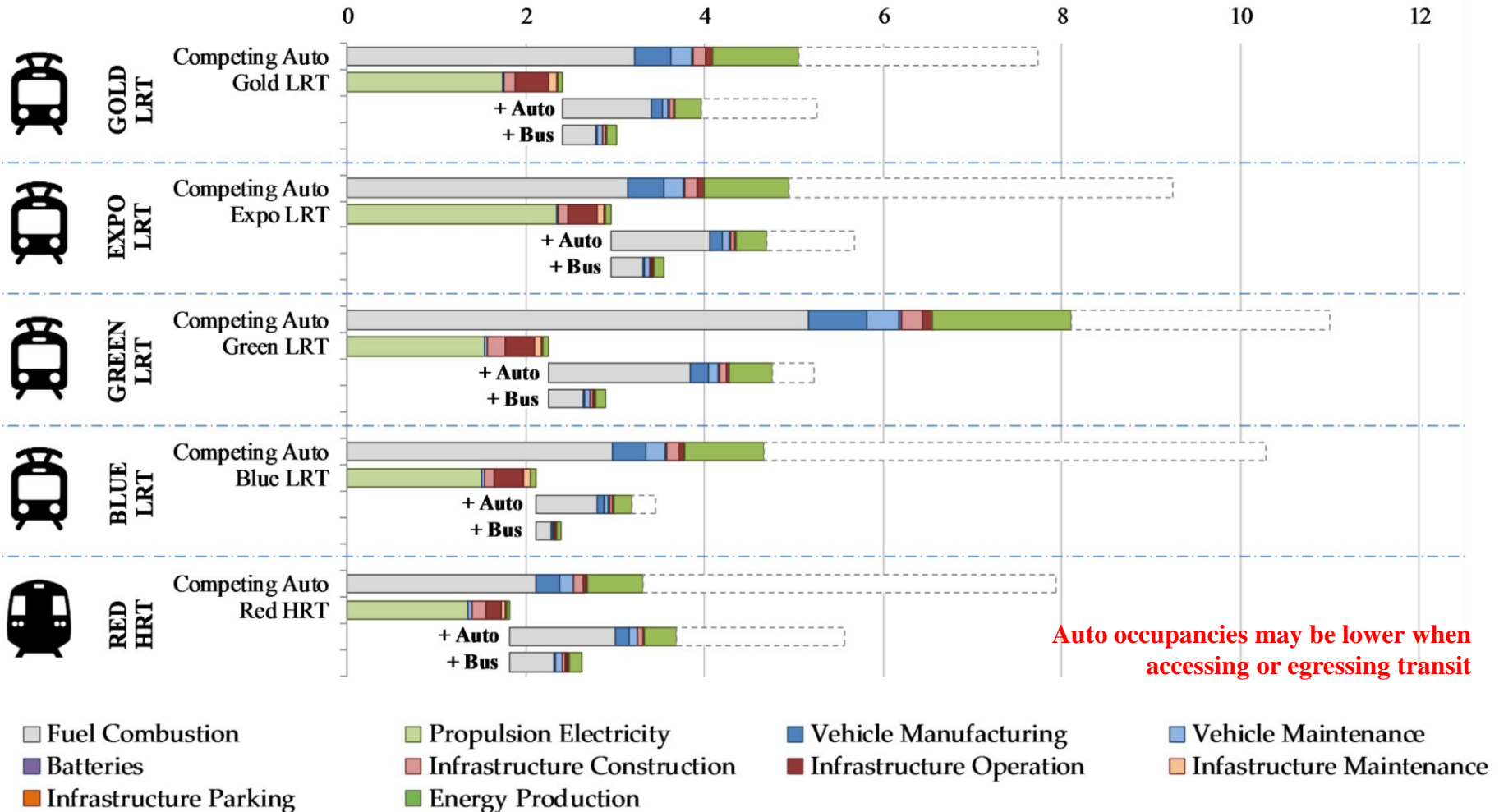


Note that auto trips in LA are ~2 pax per trip

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

GHGs per Passenger-Trip

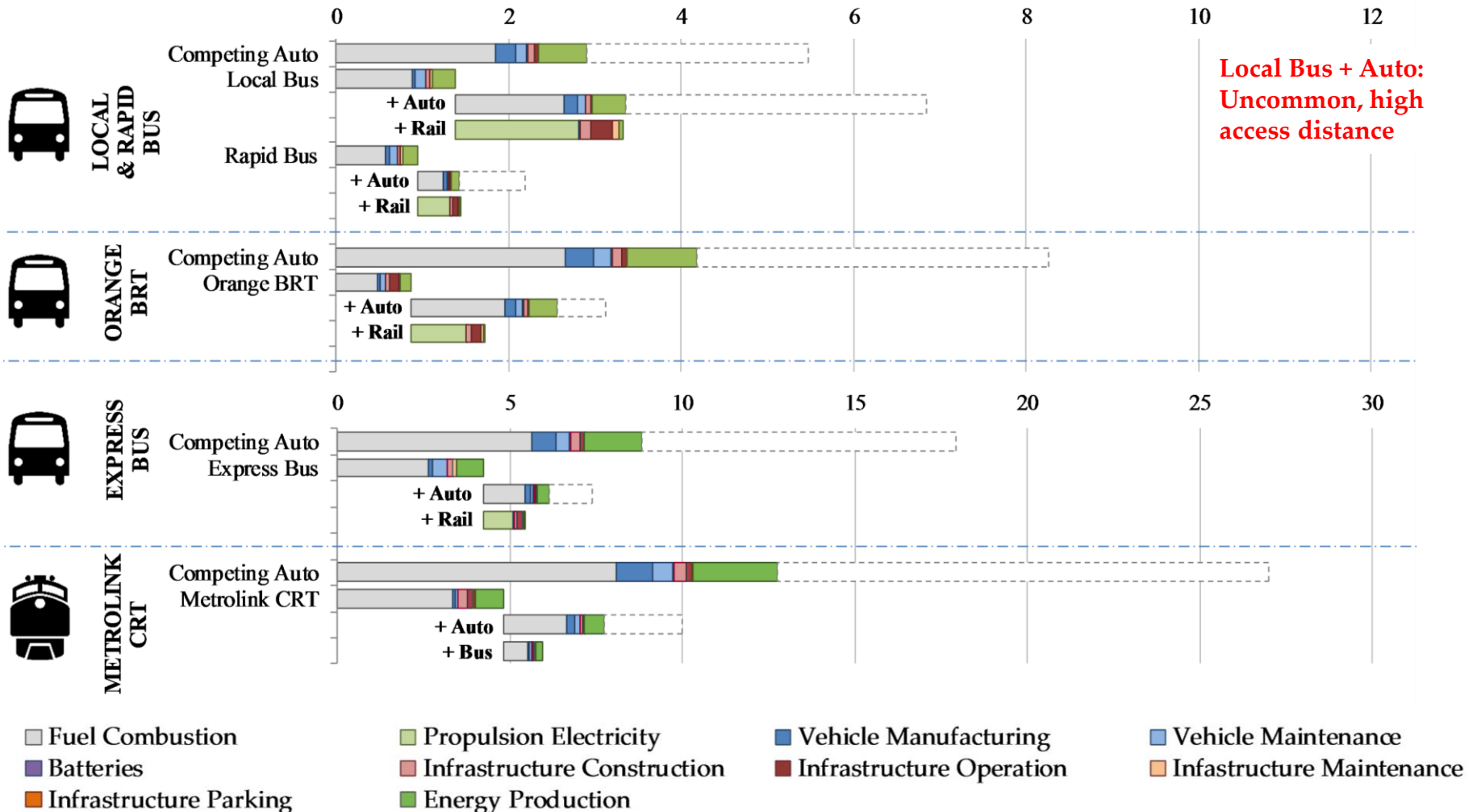
GREENHOUSE GAS EMISSIONS (kg CO₂e per passenger trip)



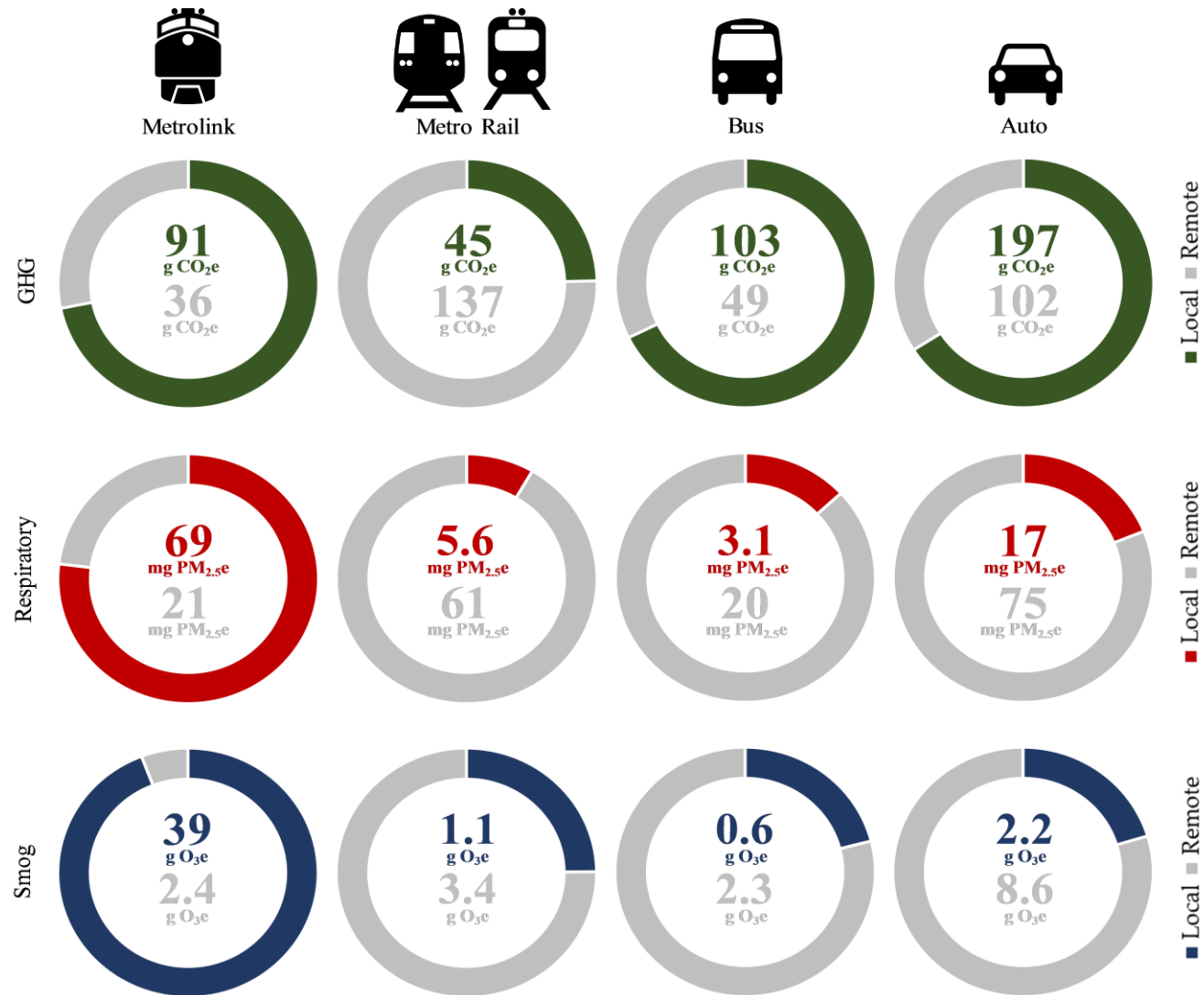
Auto occupancies may be lower when accessing or egressing transit

GHGs per Passenger-Trip

GREENHOUSE GAS EMISSIONS (kg CO₂e per passenger trip)

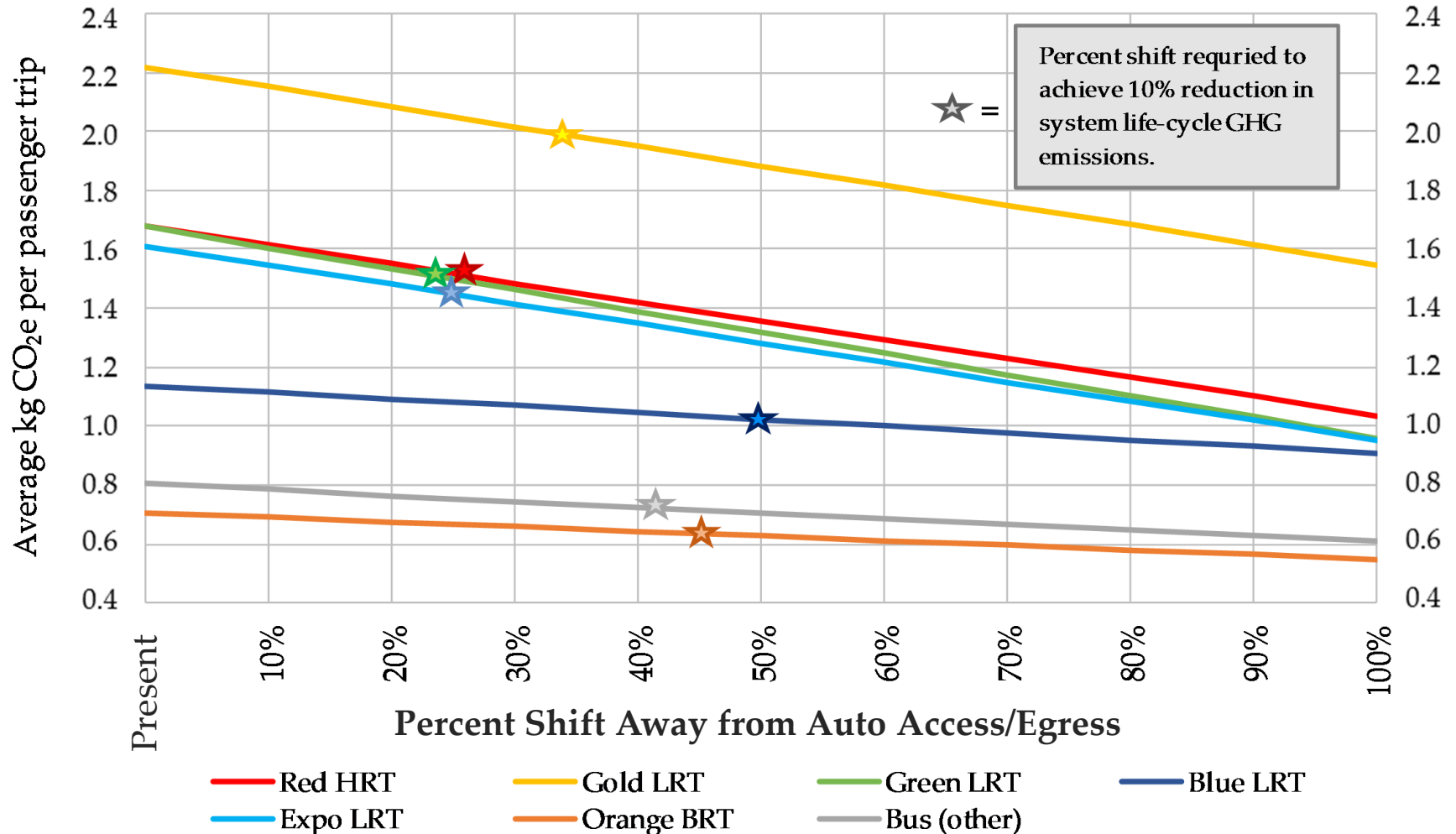


Local vs Remote Impacts Per Passenger Trip



Reducing 10% of GHG Impacts

Average GHG emissions per passenger trip vs auto shift



la.transportationlca.org

REPORT and DATA



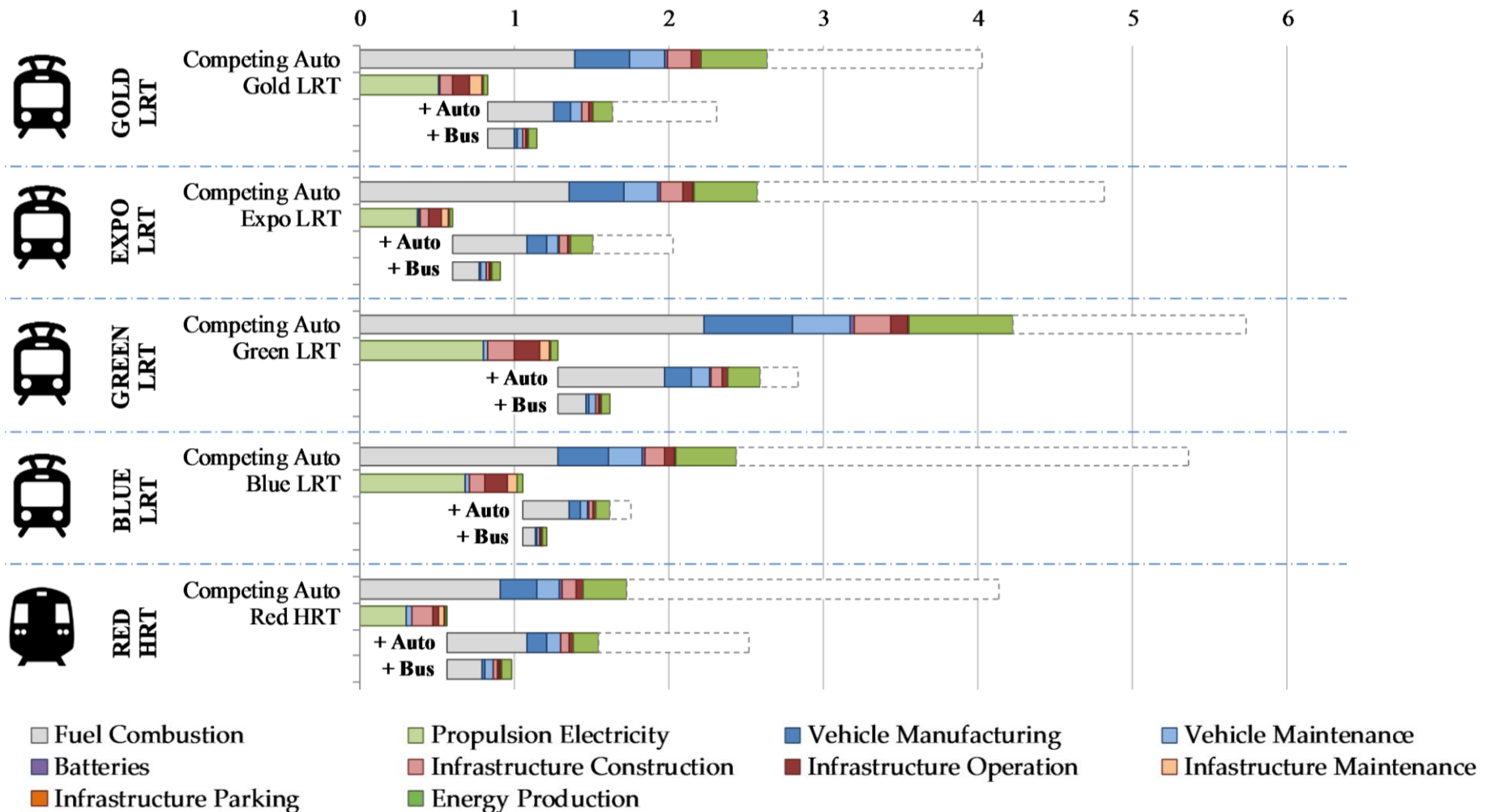
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GHGs per Passenger-Trip (Long Term)

GREENHOUSE GAS EMISSIONS (kg CO₂e per passenger trip)



GHGs per Passenger-Trip (Long Term)

GREENHOUSE GAS EMISSIONS (kg CO₂e per passenger trip)

