Rail Concrete and Steel Use from a Life Cycle Lens

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VEHICLE USE

INFRASCTURE

ENERGY PRODUCTION

INTERDEPENDENCIES

SUPPLY CHAINS

COMPLEXITY
<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>ONROAD</th>
<th>RAIL</th>
<th>AIR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturing</strong></td>
<td>Vehicle</td>
<td>Train Manufacturing</td>
<td>Aircraft</td>
</tr>
<tr>
<td></td>
<td>Transport to Point of Sale</td>
<td>Transport to Point of Sale</td>
<td>Engine</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td>Propulsion</td>
<td>Propulsion + Auxiliaries</td>
<td>Propulsion (Flight Stages)</td>
</tr>
<tr>
<td></td>
<td>Idling</td>
<td>Idling ( Stops+Warm Running)</td>
<td>Idling</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>Typical Sedan Maintenance</td>
<td>Typical Train Maintenance</td>
<td>Typical Aircraft Maintenance</td>
</tr>
<tr>
<td></td>
<td>Tire Replacement</td>
<td>Train Cleaning</td>
<td>Engine Maintenance and Replacement</td>
</tr>
<tr>
<td></td>
<td>Battery Replacement</td>
<td>Flooring Replacement</td>
<td></td>
</tr>
<tr>
<td><strong>Insurance</strong></td>
<td>Vehicle Liability</td>
<td>Crew health and benefits</td>
<td>Crew health and benefits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Train liability</td>
<td>Aircraft liability</td>
</tr>
<tr>
<td><strong>INFRASTRUCTURE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Construction</strong></td>
<td>Roadway construction</td>
<td>Station construction</td>
<td>Airport construction</td>
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<tr>
<td></td>
<td></td>
<td>Track construction</td>
<td>Runway/Taxiway/Tarmac construction</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td>Roadway lighting</td>
<td>Station lighting</td>
<td>Runway lighting</td>
</tr>
<tr>
<td></td>
<td>Herbicide spraying</td>
<td>Escalators</td>
<td>Deicing fluid production</td>
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<tr>
<td></td>
<td>Roadway salting</td>
<td>Train control</td>
<td>GSE operation</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>Roadway maintenance</td>
<td>Station maintenance</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Station cleaning</td>
<td></td>
</tr>
<tr>
<td><strong>Parking</strong></td>
<td>Roadside, surface lot, and parking garage</td>
<td>Station parking</td>
<td></td>
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<tr>
<td></td>
<td>parking</td>
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<tr>
<td><strong>Insurance</strong></td>
<td></td>
<td>Non-crew health insurance and benefits</td>
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<td></td>
<td></td>
<td>Infrastructure liability insurance</td>
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<td></td>
<td></td>
<td>Infrastructure liability</td>
<td></td>
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<tr>
<td><strong>ENERGY PRODUCTION</strong></td>
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</tr>
<tr>
<td><strong>Extraction, Processing, &amp; Distribution</strong></td>
<td>Gasoline Extraction, Processing, &amp; Distribution</td>
<td>Diesel or Electricity Raw Fuel Extraction, Processing, Generation, Transmission, &amp; Distribution</td>
<td>Raw Fuel Extraction and Processing, Electricity Generation, Transmission &amp; Distribution</td>
</tr>
</tbody>
</table>
LIFE-CYCLE GREENHOUSE GAS EMISSIONS
(grams CO$_2$e/Passenger Kilometer Traveled)


For rail modes, infrastructure is 30-49% of life-cycle GHG emissions.
There’s no one-size-fits-all approach when it comes to assessing transportation infrastructure, especially rail (diversity of systems, design conditions, etc).

Data points in life-cycle models are not necessarily representative.

Chester/Horvath model continues to be the only bottom-up model for transportation infrastructure life-cycle modeling.
At-Grade

Los Angeles Metro, Gold Line Environmental Impact Statement, 1988
Tunnel

Los Angeles Metro,
Gold Line
Environmental Impact Statement, 1988
Below Grade

Los Angeles Metro, Gold Line
Environmental Impact Statement, 1988
Aerial

Los Angeles Metro, Gold Line Environmental Impact Statement, 1988
Legacy Infrastructure

Griest (1915), New York City
Stations
High-speed rail with emerging automobiles and aircraft can reduce environmental impacts in California’s future

Mikhail V. Chester

Los Angeles, Chicago, New York, Boston, San Francisco, Phoenix, California, New England

Passenger and Freight

Light Rail, Heavy Rail, Commuter Rail, High-speed Rail
Passenger Rail

Concrete & Steel
<table>
<thead>
<tr>
<th>CONCRETE</th>
<th>STEEL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STATIONS</strong></td>
<td>Aerial (platforms, pier caps, columns, footings); Surface (platforms, footings); Elevated (platforms, footings); Underground (floor caps, roof caps, footings, walls).</td>
</tr>
<tr>
<td><strong>TRACKS</strong></td>
<td>Surface (retaining walls, ground slab); Subway (walls); Aerial (supports, footings); Ties.</td>
</tr>
</tbody>
</table>
Materials Comparison in Rail Infrastructure

Stations

SURFACE
- Concrete (m$^3$/station): 140 (street-level) to 1,700 (elevated); 12,000 for HSR
- Steel (kg/station): 36 (street-level) to 420 (elevated); 3,100 for HSR

AERIAL
- Concrete (m$^3$/station): 620 to 15,000
- Steel (kg/station): 160 to 3,700

UNDERGROUND
- Concrete (m$^3$/station): 8,600 to 22,000
- Steel (kg/station): 2,100 to 5,400
Materials Comparison in Rail Infrastructure

Tracks

**SURFACE**
- Concrete (m³/km): 140 to 560 (high of 4,800 for LA Expo with concrete for ballast)
- Steel (kg/km): 35 to 140 (high of 1,200 for LA Expo)

**AERIAL**
- Concrete (m³/km): 5,600 to 6,600 (high of 20,000 for LA Expo)
- Steel (kg/km): 1,400 to 1,600 (high of 5,000 for LA Expo)

**UNDERGROUND**
- Concrete (m³/km): 2,400
- Steel (kg/km): 590
By 2026...

- Expo has added 267 Gg CO₂e
- Avoided automobile emissions are equivalent

Post 2026 Expo is reducing LA’s GHG emissions.
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www.transportationlca.org