THE IMPORTANCE OF INFRASTRUCTURE IN TRANSPORT LCA
And how to consider it

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Simplified chronology of LCA for transportation systems: the modal approach is 10 years old

**THE 1990s: INITIATION**

- LCAs of roads & automobiles
- 1st road LCA: 1996

**THE 2000s: SYSTEMATIZATION AND MODAL INTEGRATION**

- PaLATE and Gaia BE tools: 2007
- Ecorce and SEVe: 2009

**THE 2010s: EXPANSION, COMPLETION AND CONTEXTUALIZATION**

- Enhanced modelling of the road use phase: 2012
- ROAD USE PHASE MODAL AND TERRITORIAL APPROACHES SPATIALIZATION
- 1st consequential LCA: 2013*
- 1st intermodal LCA: 2017*

**1ST CASE STUDIES AND ACADEMIC METHODOLOGY**

- American study: 2000
- 1st Volkswagen case study: 2007
- Diesel, hydrogen and electric powertrains: 2008*
- 1st complete mode LCA

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de Bortoli et al. 2018
Primary energy consumption for a standard road lifespan (infrastructure + traffic, 30y, AADT=4000)

- the infrastructural impact of road transportation is in average pretty low
- In the US, 5% of the transportation GHG emissions (Van dam et al. 2015)

➤ So why bothering with infrastructure LCA?
So why should we consider the infrastructure in transport LCA? Evidence #1 – roads: how are they used?

LCA of the Martinique Bus Rapid Transit - contribution to the different impact categories of each BRT subsystem

*de Bortoli et al. 2017*
Why should we consider infrastructure in transportation LCA? Evidence #2 – roads: how will they be used?

- Depletion of fossil resources => vehicles used: electromobility, microvehicles

Normalized environmental comparison of 4 Parisian micromobility modes to other competitive urban modes (in Swiss and European contexts, compared to the hoverboard)

de Bortoli et al. (Under review)
So why should we consider the infrastructure in transport LCA?

Evidence #3 – electric rail modes (GHG contributions)
Considering the infrastructure in transportation LCA is mandatory

1. Because it can already represent a substantial part of the modal environmental impacts, especially:
   - On roads with low traffic
   - For rail modes using (low-carbon) electricity for propulsion

2. Because of the energy transition, and its impacts on mobility behaviors/technologies/policies
   - The impact of the infrastructure will probably be higher and higher

3. Because of the infrastructure-vehicle interactions
HOW TO CONSIDER THE INFRASTRUCTURE IN URBAN MOBILITY LCA?

1. Assessing the infrastructure section/network
2. Allocating its impact to vehicles
HOW TO CONSIDER THE INFRASTRUCTURE IN URBAN MOBILITY LCA?

1. Assessing the infrastructure section/network

2. Allocating its impact to vehicles
State-of-the-art - Roads

• Well advanced

• Variability parameters (AzariJafari et al. 2018)
  • Materials: concrete or asphalt, asphalt mixing temperature, alternative materials
  • Machinery efficiency
  • Proportion of recyclable materials

• But case-specificities (geographical and technological context)

• And some inconsistencies in the litterature:
  • Definition of the functional unit
  • Selection of different life cycle stages

• Environmental factors must be chosen attentively
# State-of-the-art – railways

<table>
<thead>
<tr>
<th>Type of Rail</th>
<th>Number of Cases</th>
</tr>
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<tbody>
<tr>
<td>Commuter</td>
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<tr>
<td>HRT</td>
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</tr>
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<td>25</td>
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<tr>
<td>Intercity</td>
<td>11</td>
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<td>Light Rail</td>
<td>7</td>
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<tr>
<td>Metro</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>57</strong></td>
</tr>
</tbody>
</table>

*Olungbenga et al. 2019*
State-of-the-art – railways: high variabilities

Figure 5: Embodied GHG Emissions reported for the different rail infrastructure

Olungbenga et al. 2019
Table 7 Mean of the embodied GHG emissions (tCO2) per kilometre of at-grade with their standard error

<table>
<thead>
<tr>
<th>Type of Rail</th>
<th>Number of Cases</th>
<th>Mean of the embodied GHG emissions (tCO2)</th>
<th>Standard Error</th>
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<td>4026</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>1400</td>
<td>268</td>
</tr>
</tbody>
</table>

Olungbenga et al. 2019
HOW TO CONSIDER THE INFRASTRUCTURE IN URBAN MOBILITY LCA?

1. Assessing the infrastructure section/network
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How to allocate the infrastructural burdens to vehicles/modes?

• Sharing the burden between vehicle types/uses
• Considering all the different kinds of infrastructure

\[ EF_{mode,i} = EF_{veh,i} + EF_{infra,i} = \frac{EF_{1veh,i}}{PKT_{1veh,i}} + \sum_j a_{ij} q_j \cdot EF_{1u,infra,j} \]

• \( a_{ij} \) = allocation factor attributing a share of the burden from the infrastructure j to the mode i
How to calculate the allocation factors

- **Ecoinvent proposal** for roads and rail:
  - Infra life cycle burden allocated linearly to the Gross Vehicle Weight
  \[
  a_{ij} = \frac{1}{PKT_{ij}} \cdot \frac{b_{ij}VKT_{ij}}{\sum_i b_{ij}VKT_{ij}}
  \]
  - Excluding the operation stage allocated on a pkt basis
- **Chester 2008**: the opposite (pp39-40)
- Need for enhancement?
EX. OF ENVIRONMENTAL IMPACTS OF THE INFRASTRUCTURE ON URBAN MODES OF TRANSPORT

Chester's work – transportationlca.org
In a nutshell: transportation infrastructure

- Its environmental impact has been (largely) investigated
- But infrastructure are not common goods
- Thus variability are high (and uncertainty too)
- Advice for an integrated tool:
  - Methodological transparency – infra & traffic assumptions - when giving an environmental impact,
  - Consistency between the modal components (allocation, LCIA$s$, background dataset)
  - Regionalization?
THANK YOU FOR YOUR ATTENTION

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Variabilities in road LCAs

Representation of the two main stage contributors to the environmental impacts of resurfacing by type of indicator, type of asphalt mix, and study

de Bortoli (Under review)
Sensitivity of the environmental performance ranking to the passenger occupancy (and level of service)