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

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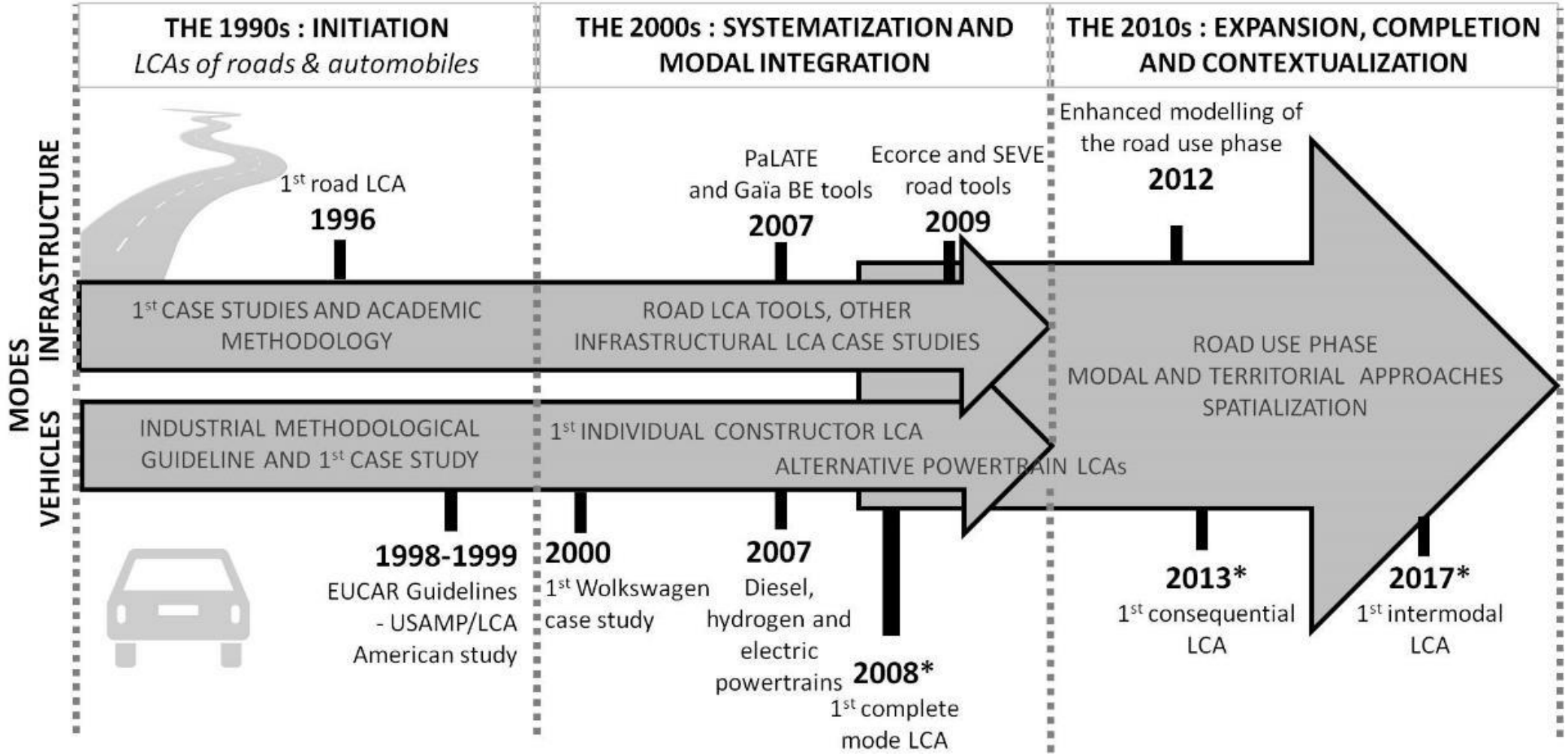
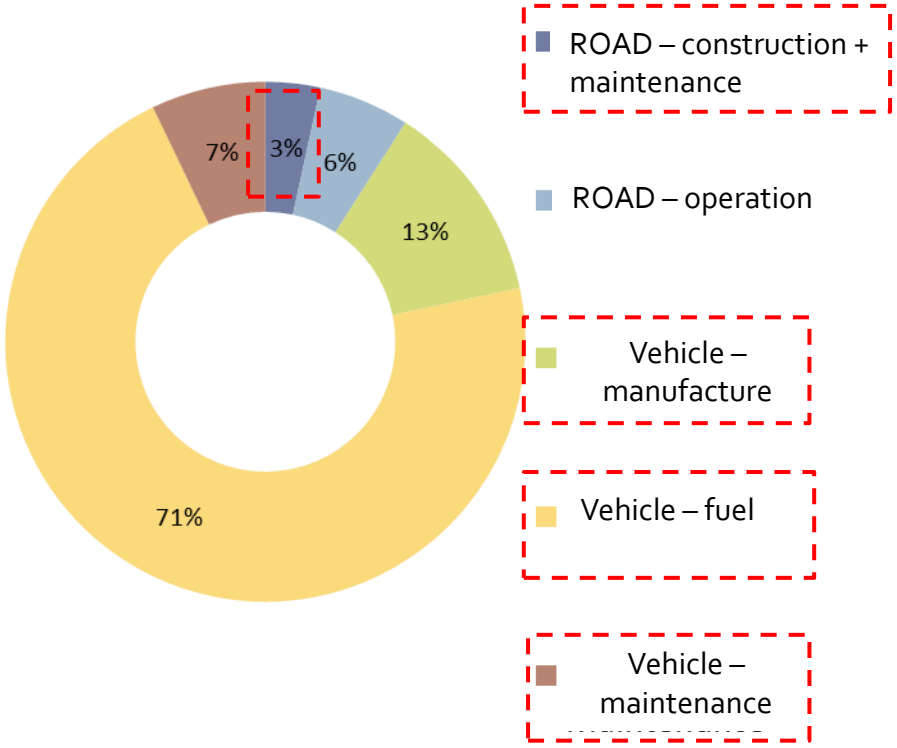
Simplified chronology of LCA for transportation systems: the modal approach is 10 years old



de Bortoli et al. 2018

Primary energy consumption for a standard road lifespan
(infrastructure + traffic, 30y, AADT=4000)



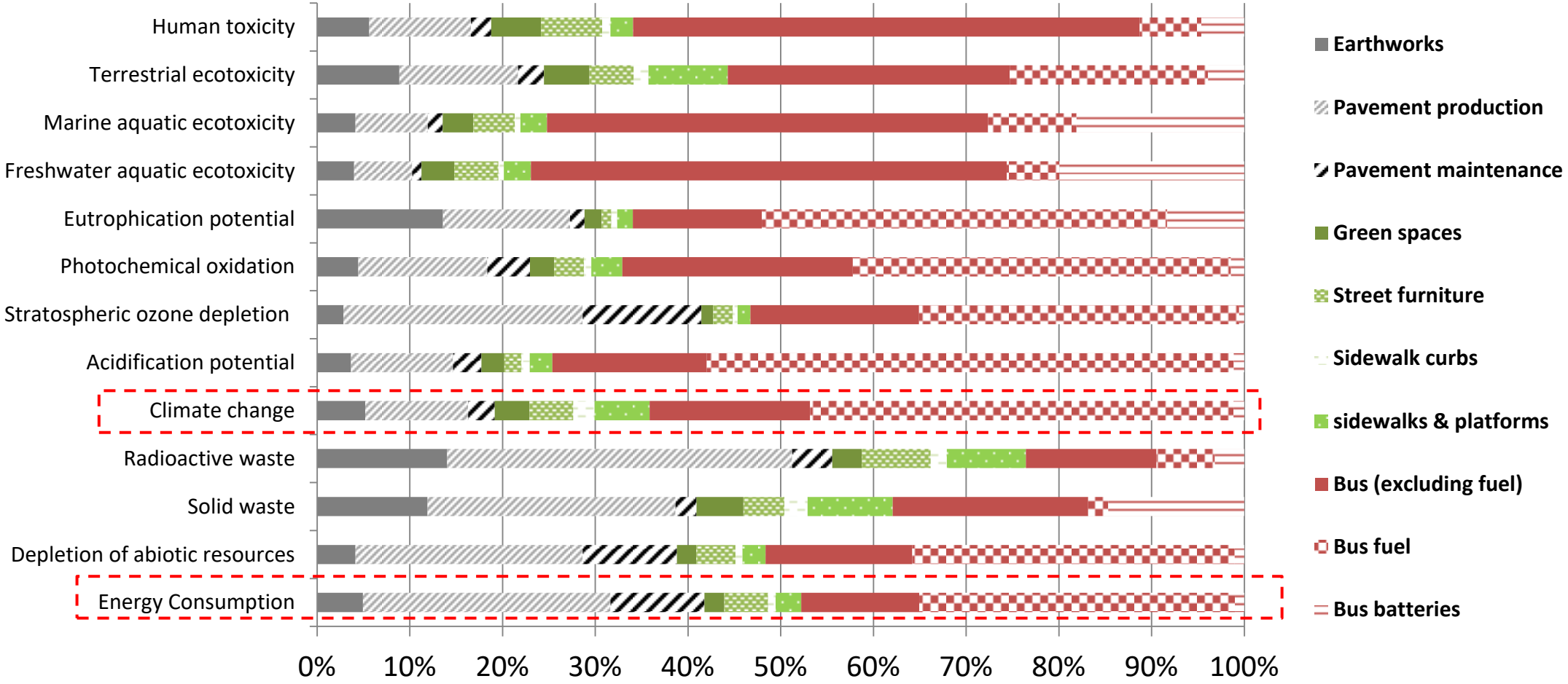
De Bortoli 2014

- 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?

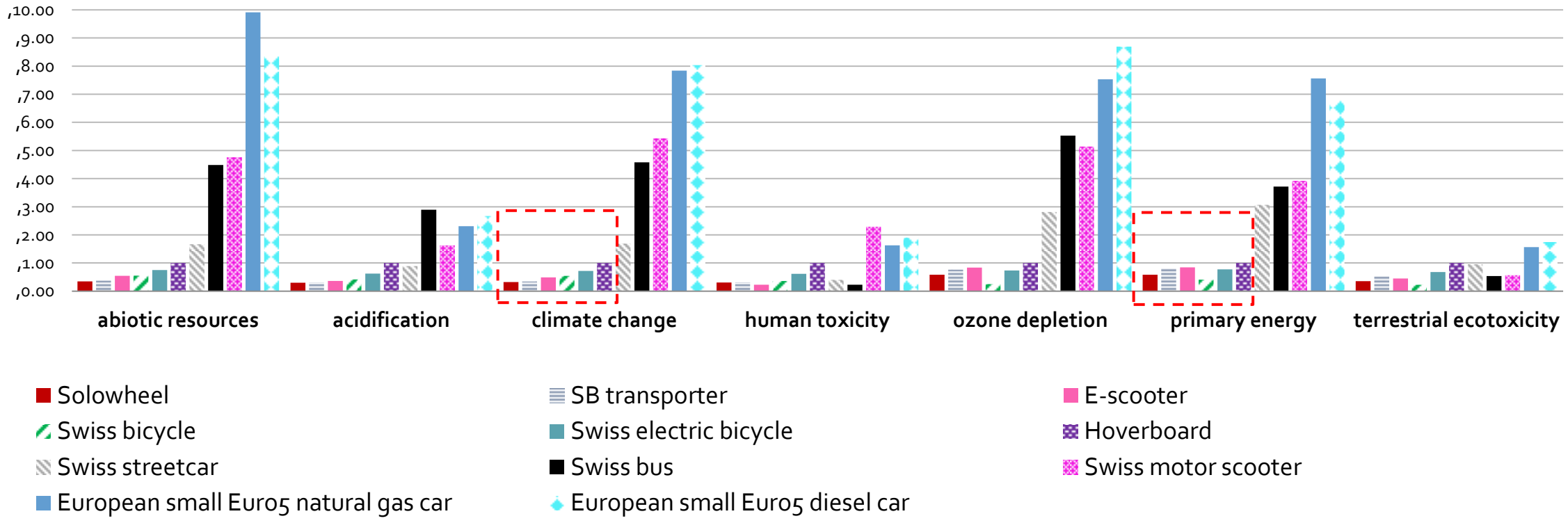


LCA of the Martinique Bus Rapid Transit - contribution to the different impact categories of each BRT subsystem

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

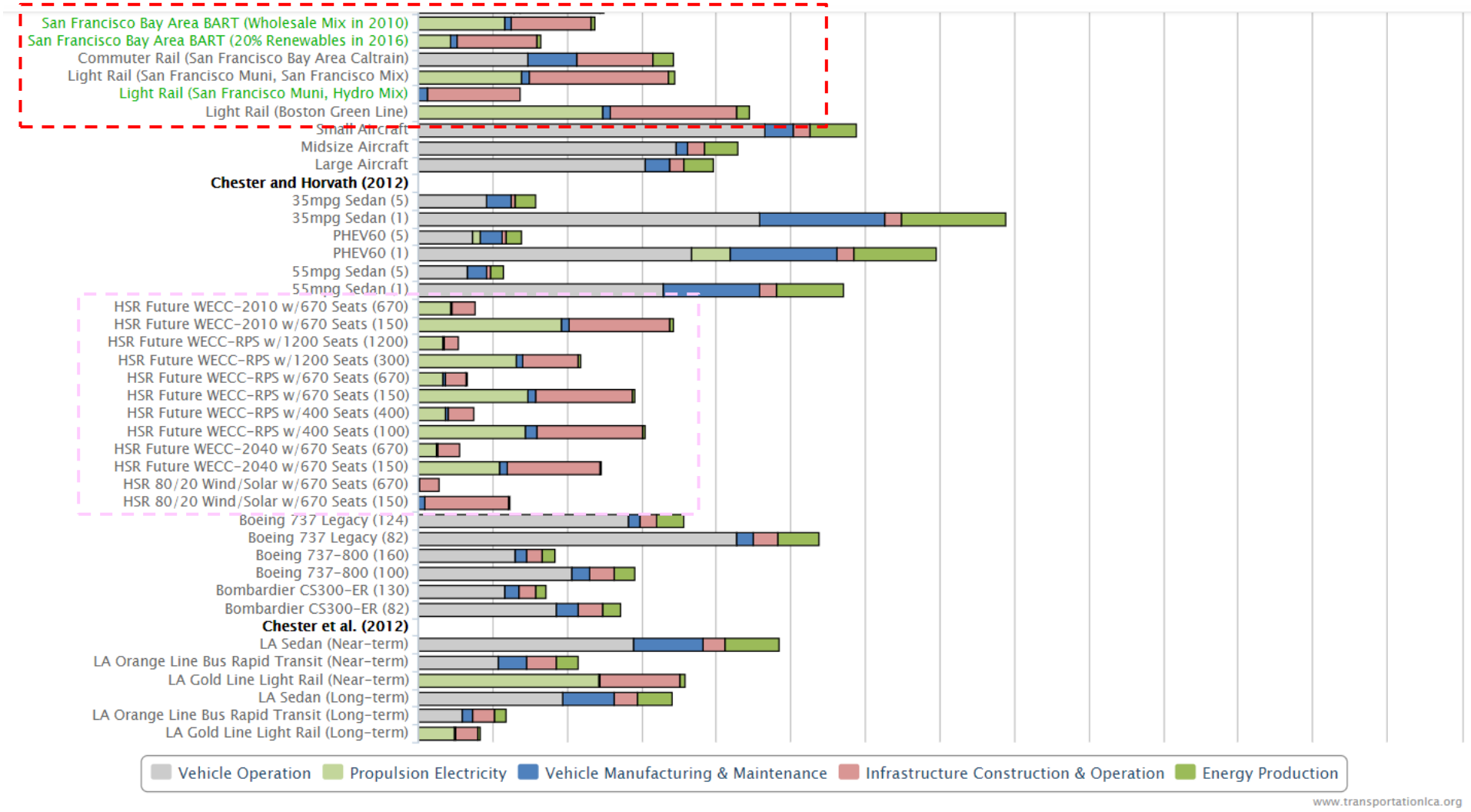


Normalized environmental comparison of 4 Parisian micromobility modes to other competitive urban modes (in Swiss and European contexts, compared to the hoverboard)

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

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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

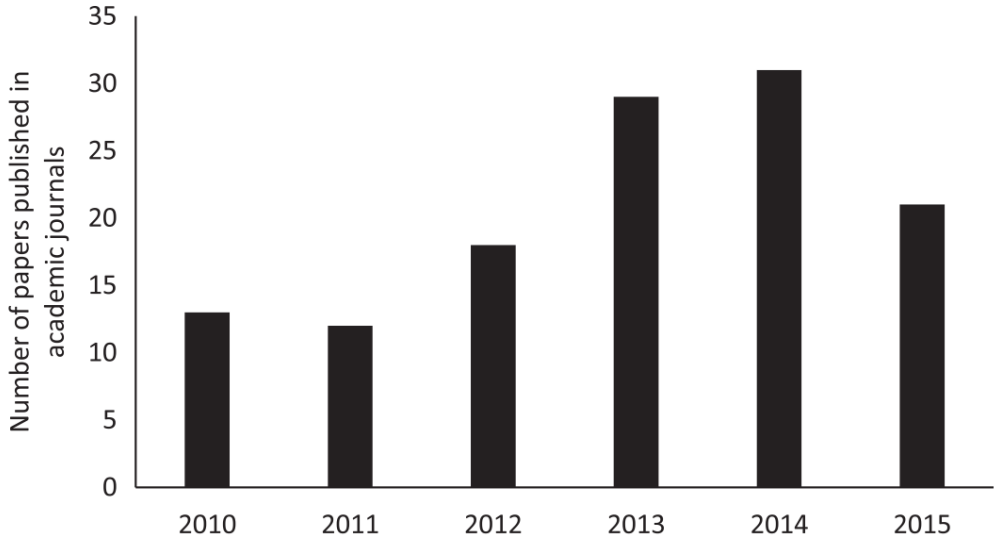

Fig. 1. Number of articles on pavement LCA since 2010 (Search on Scopus Web site on key word "life cycle assessment" AND "pavement", available by October 2015 (Scopus, 2015)).

AzariJafari et al. 2016

- 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

Type of Rail	Number of Cases
Commuter	6
Freight	1
HRT	4
HSR	25
Intercity	11
Light Rail	7
Metro	3
Total	57

Olungbenga et al. 2019

State-of-the-art – railways : high variabilities

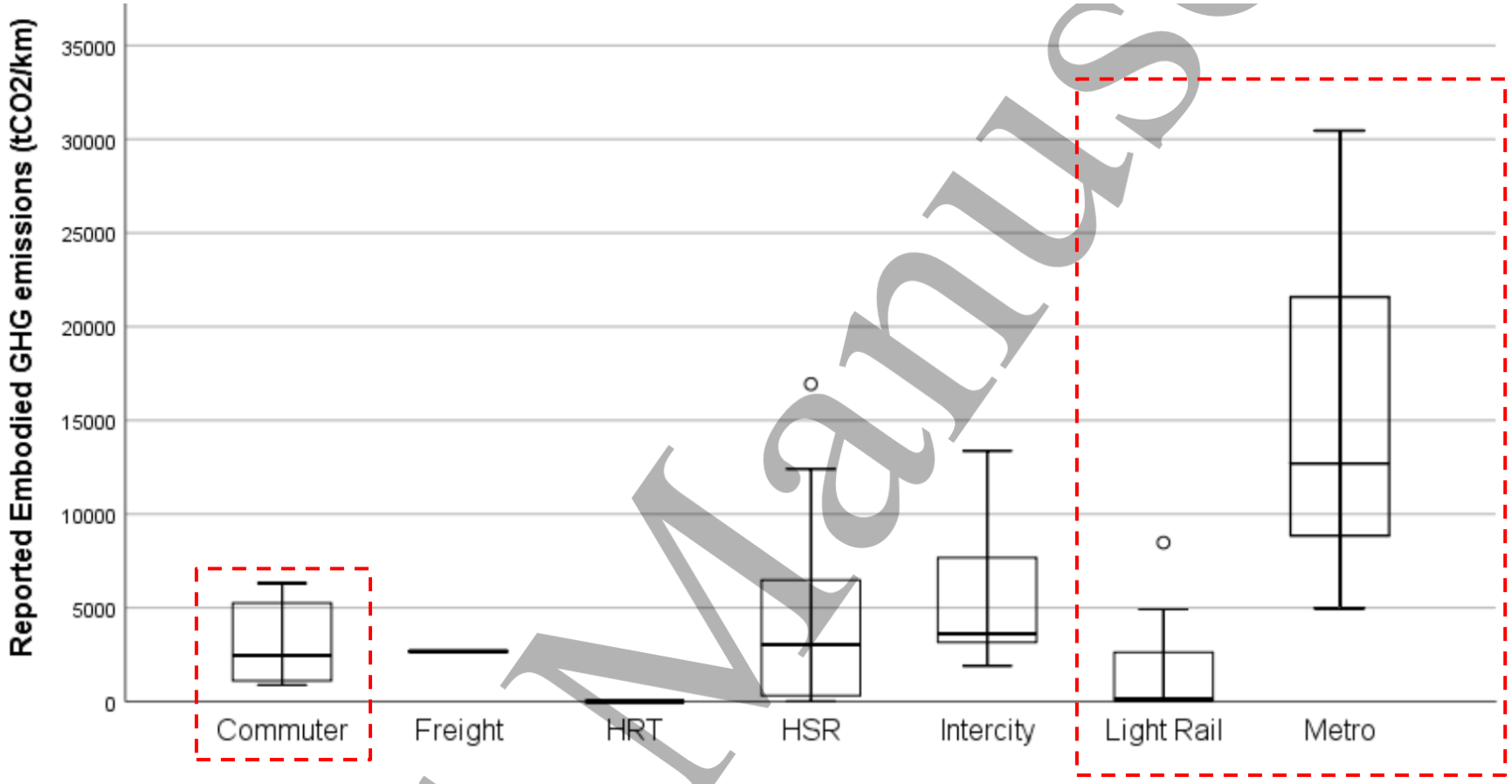

Figure 5: Embodied GHG Emissions reported for the different rail infrastructure

Olungbenga et al. 2019

State-of-the-art – railways – high uncertainty

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

Type of Rail	Number of Cases	Mean of the embodied GHG emissions (tCO2)	Standard Error
Commuter	6	2585	896
Freight	1	650	
HRT	4	2	1
HSR	25	1018	224
Intercity	11	1929	320
Light Rail	7	422	296
Metro	3	4670	4026
Total	57	1400	268

Olungbenga et al. 2019

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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

$$EF_{mode,i} = EF_{veh,i} + EF_{infra,i} = \frac{EF_{1veh,i}}{PKT_{1veh,i}} + \sum_{j} a_{ij} \underbrace{q_j . EF_{1u,infra,j}}_{\text{Network j env. burden}}$$

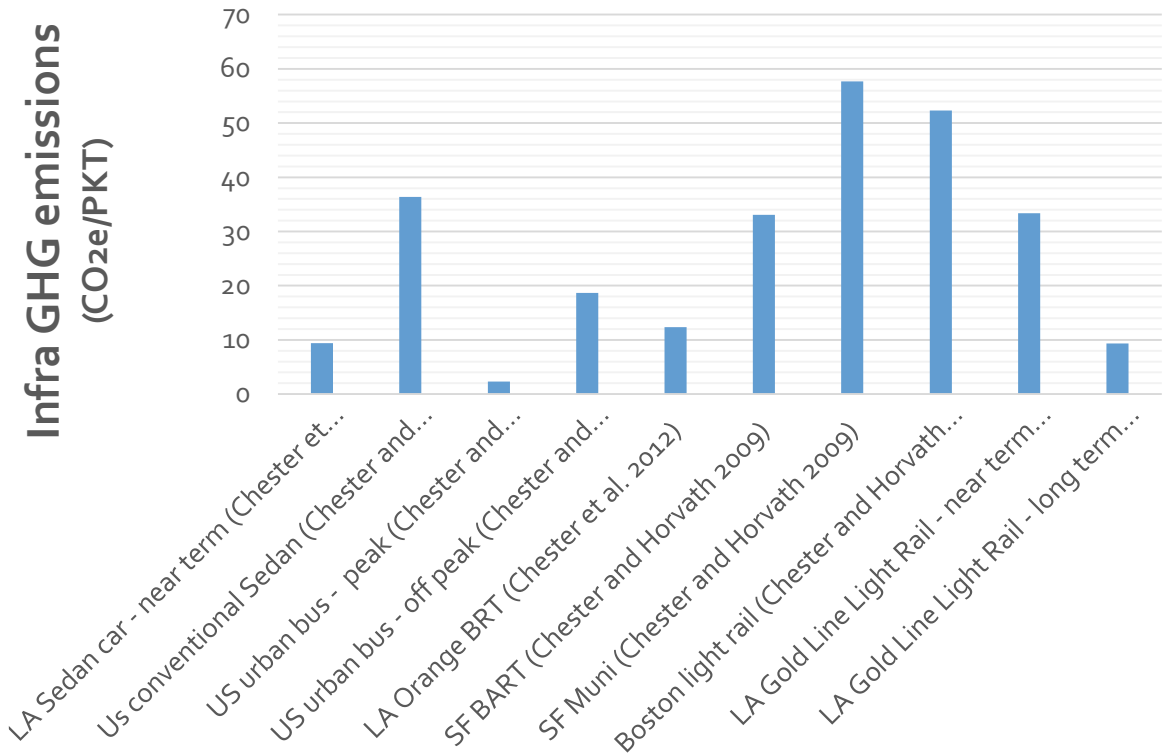
- a_{ij} = allocation factor attributing a share of the burden from the infrastructure j to the mode i

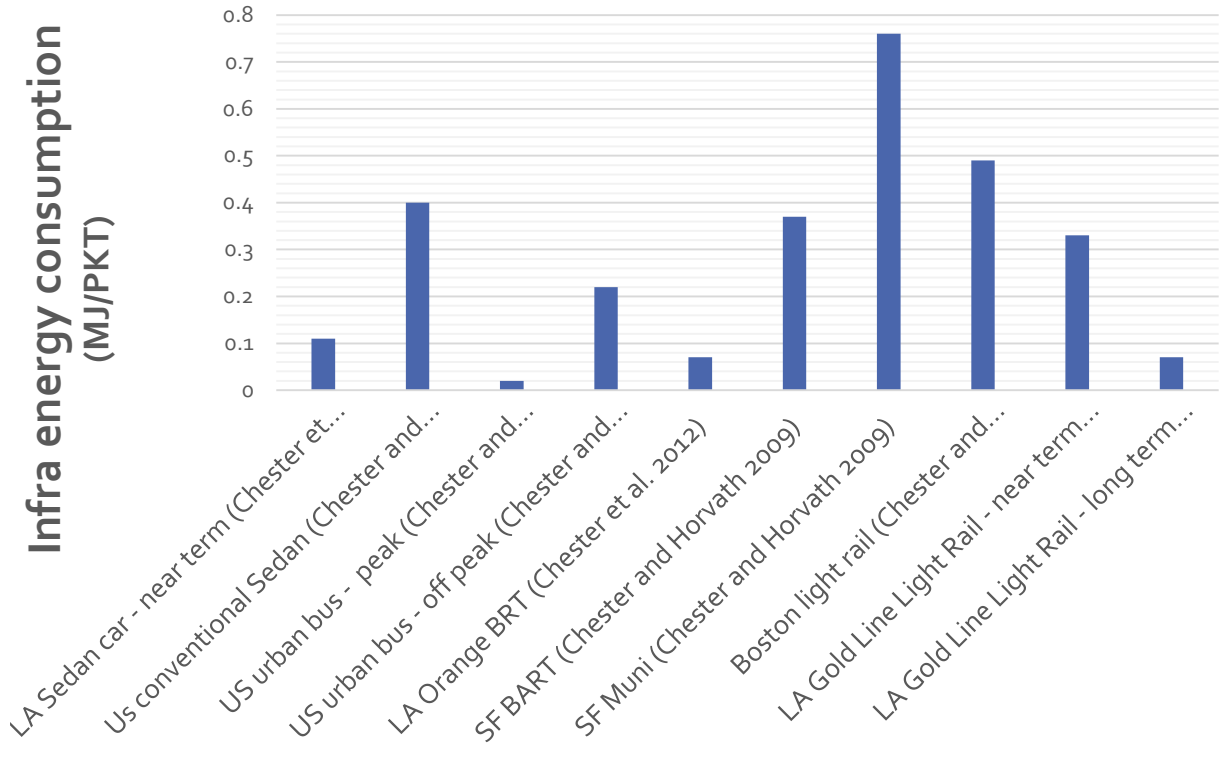
How to calculate the allocation factors

- **Ecoinvent proposal** for roads and rail :
  - Infra life cycle burden allocated linearly to the Gross Vehicle Weight

$$a_{ij} = \frac{1}{PKT_{i,j}} \cdot \frac{b_{ij}.VKT_{ij}}{\sum_i b_{ij}.VKT_{ij}}$$

  - Excluding the operation stage allocated on a pkt basis
- **Chester 2008:** the opposite (pp39-40)
- **Need for enhancement?**





Chester's work – transportationlca.org

EX. OF ENVIRONMENTAL IMPACTS OF THE INFRASTRUCTURE ON URBAN MODES OF TRANSPORT

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, LCIAs, background dataset)
  - Regionalization?

THANK YOU FOR YOUR ATTENTION

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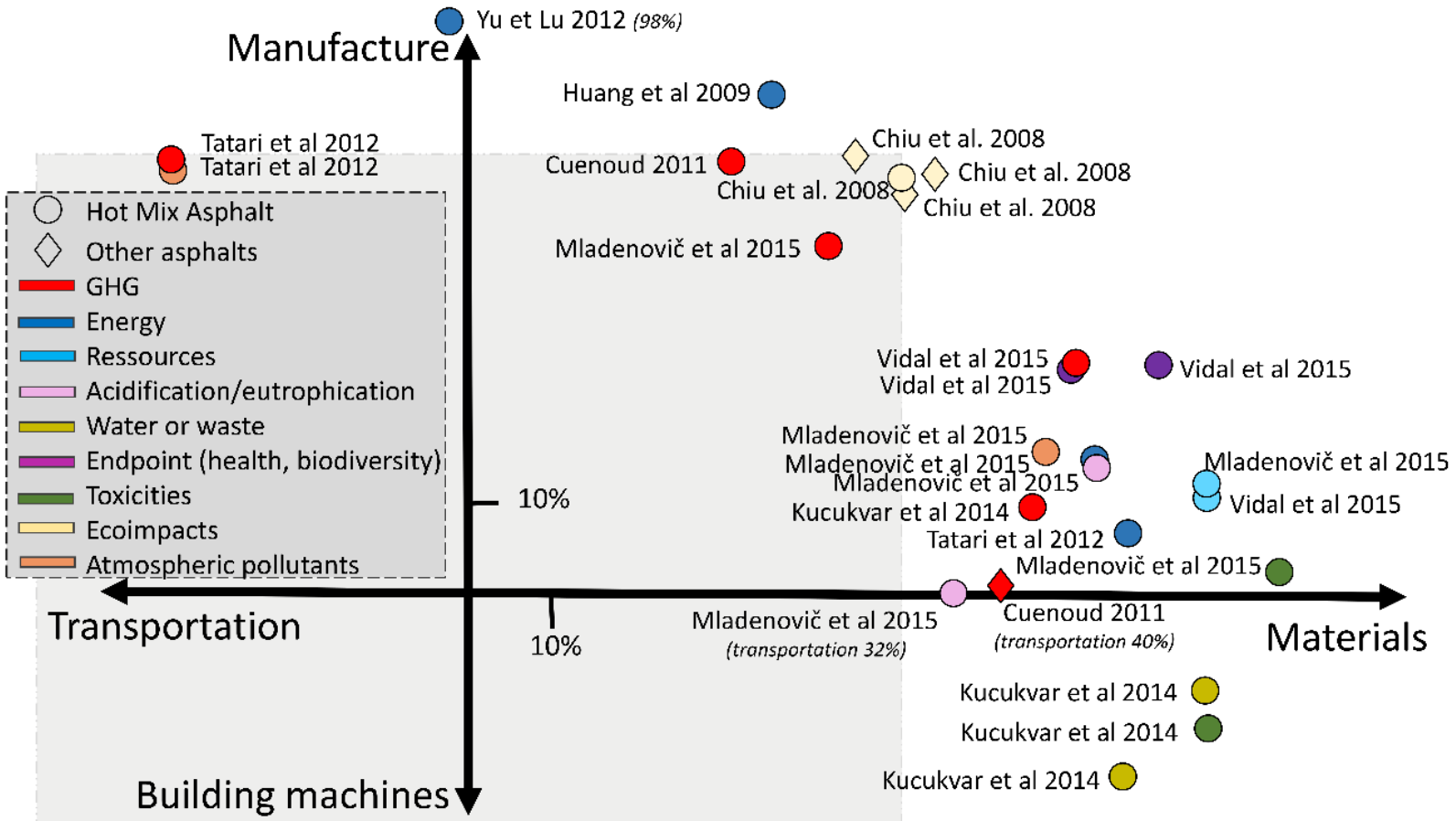
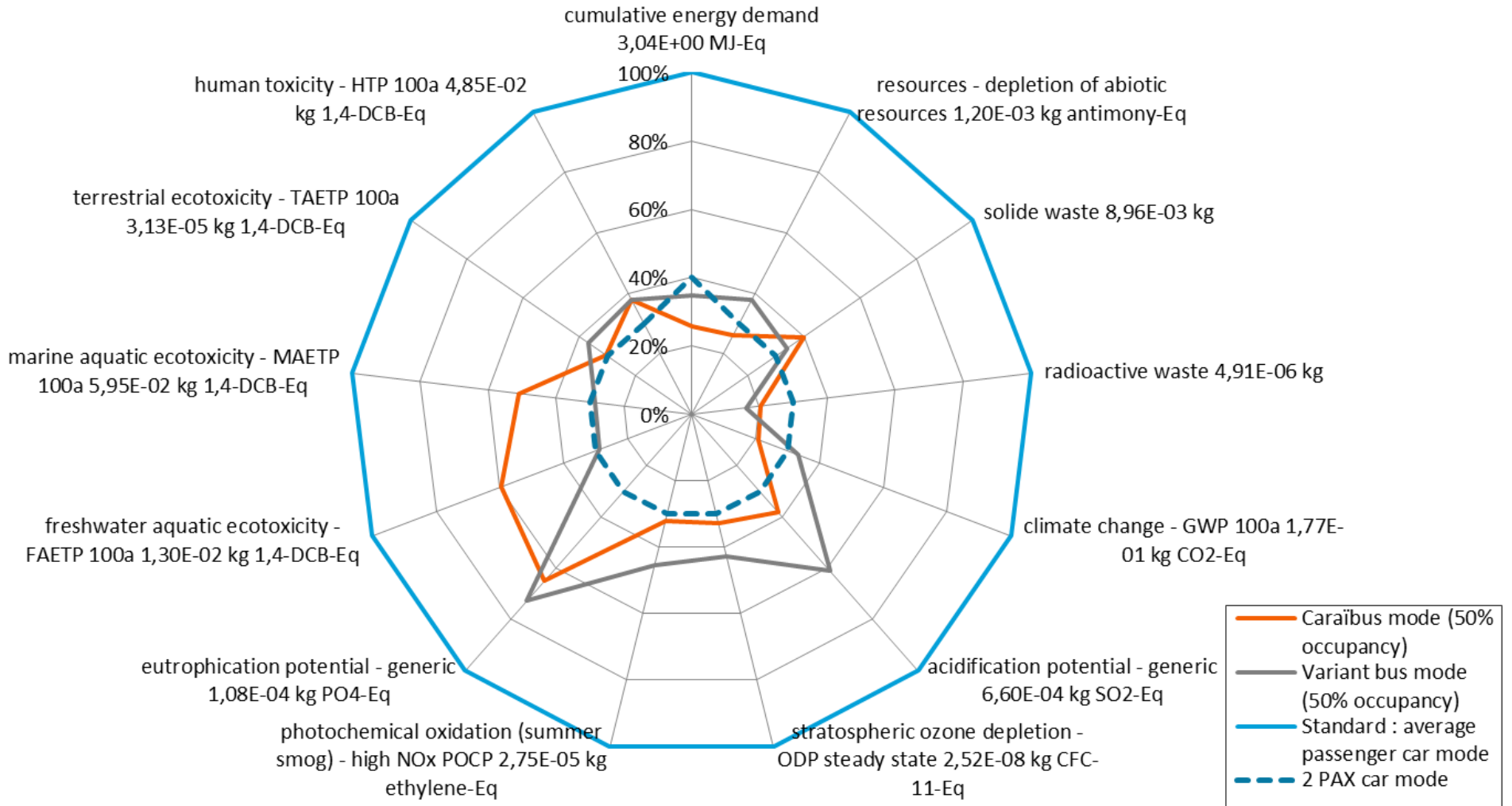
Variabilities in road LCAs



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)



de Bortoli et al. 2017