Life Cycle Assessment of Pavements

Sensitivity Analysis

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Outline:

Study Goals
Literature Review
Methodology
Phases and Components
Results

Why and How

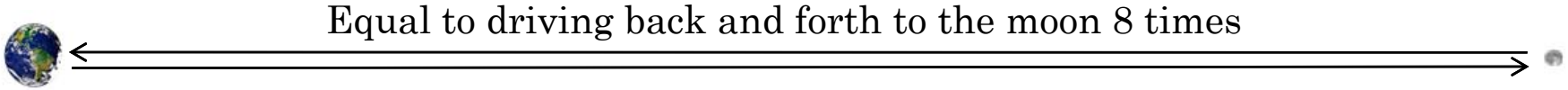
Framing the Problem

Concrete

- The most consumed material on earth after water
- Cement is the second most GHG intensive U.S. industry after steel

Transportation accounts for 29% of total U.S. GHG emissions. (EPA 2006)

Over 4 million miles of pavement in the US alone

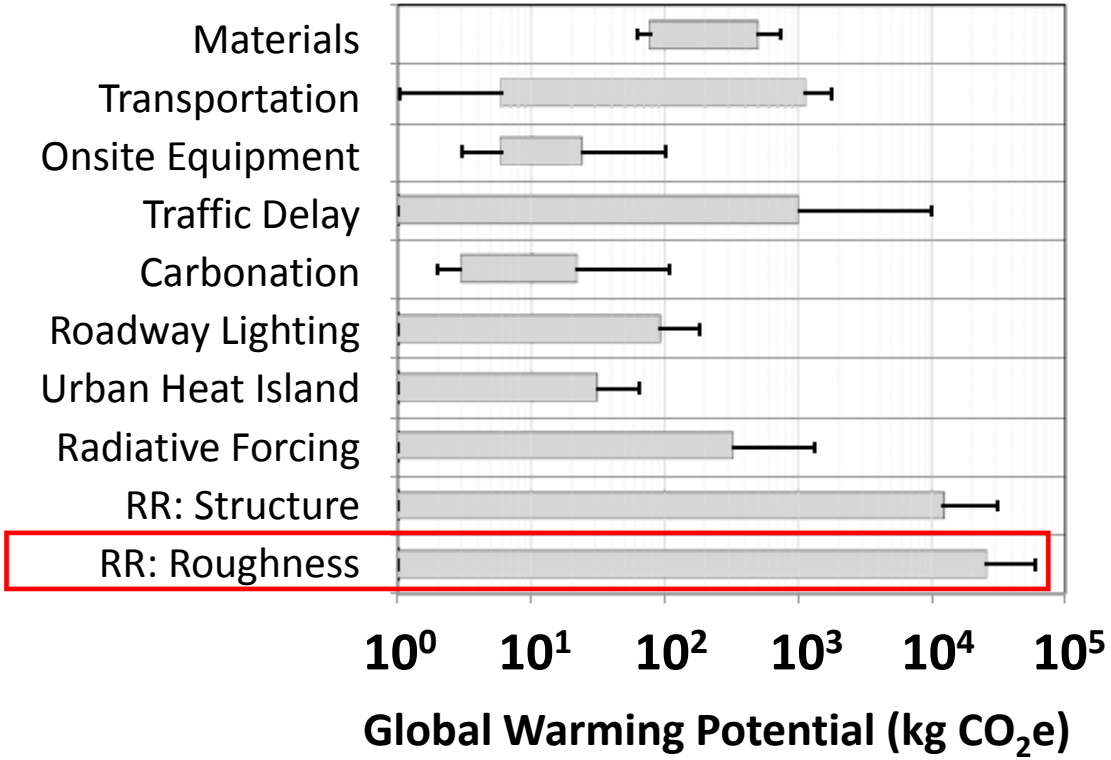


Problem statement and goals:

How do GHG emissions in the pavement life cycle vary under different **ENGINEERING** and **POLICY** scenarios and where are the largest opportunities to reduce emissions?

Literature Review

"Because the impact is context-sensitive, there is **NO SINGLE COMPONENT** that can be considered the least or most influential **UNDER ALL CIRCUMSTANCES**."



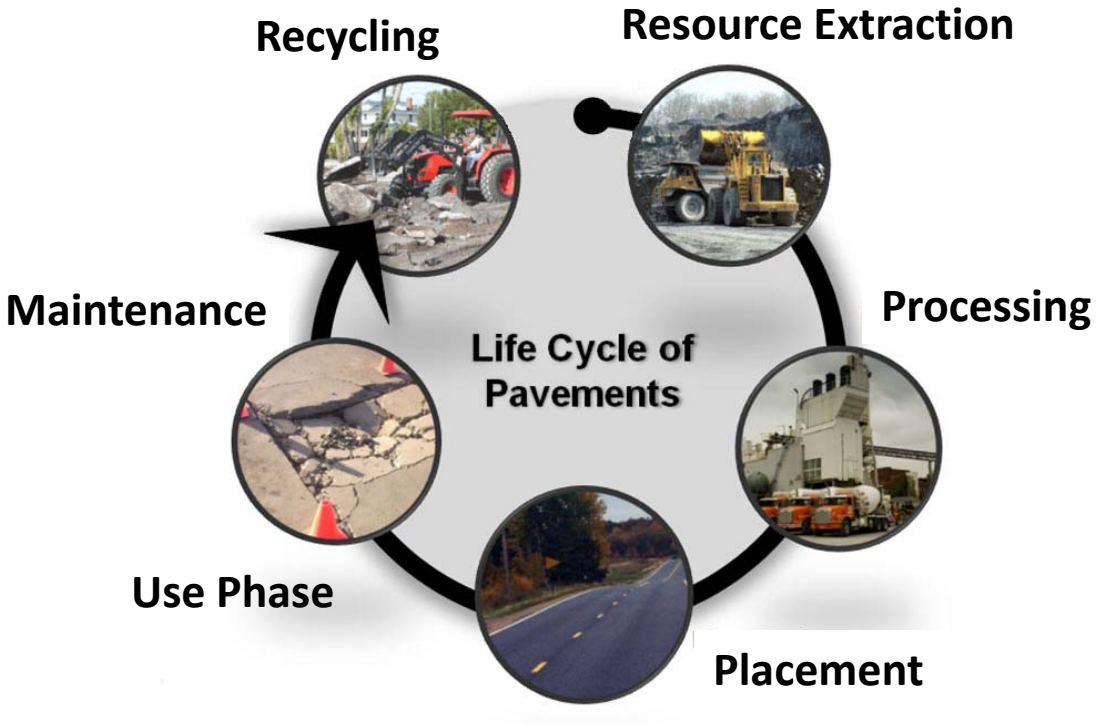
Reference:

Santero, N. J., & Horvath, Arpad (2009). *Global warming potential of pavements*. Bristol, UK: Environmental Research Letters.

Study does not include:

- Differentiation between asphalt and concrete
- Contribution from each life cycle phase
- Influence of maintenance
- Recycling/End of life

Methodology



<u>Life Cycle Assessment Framework</u>

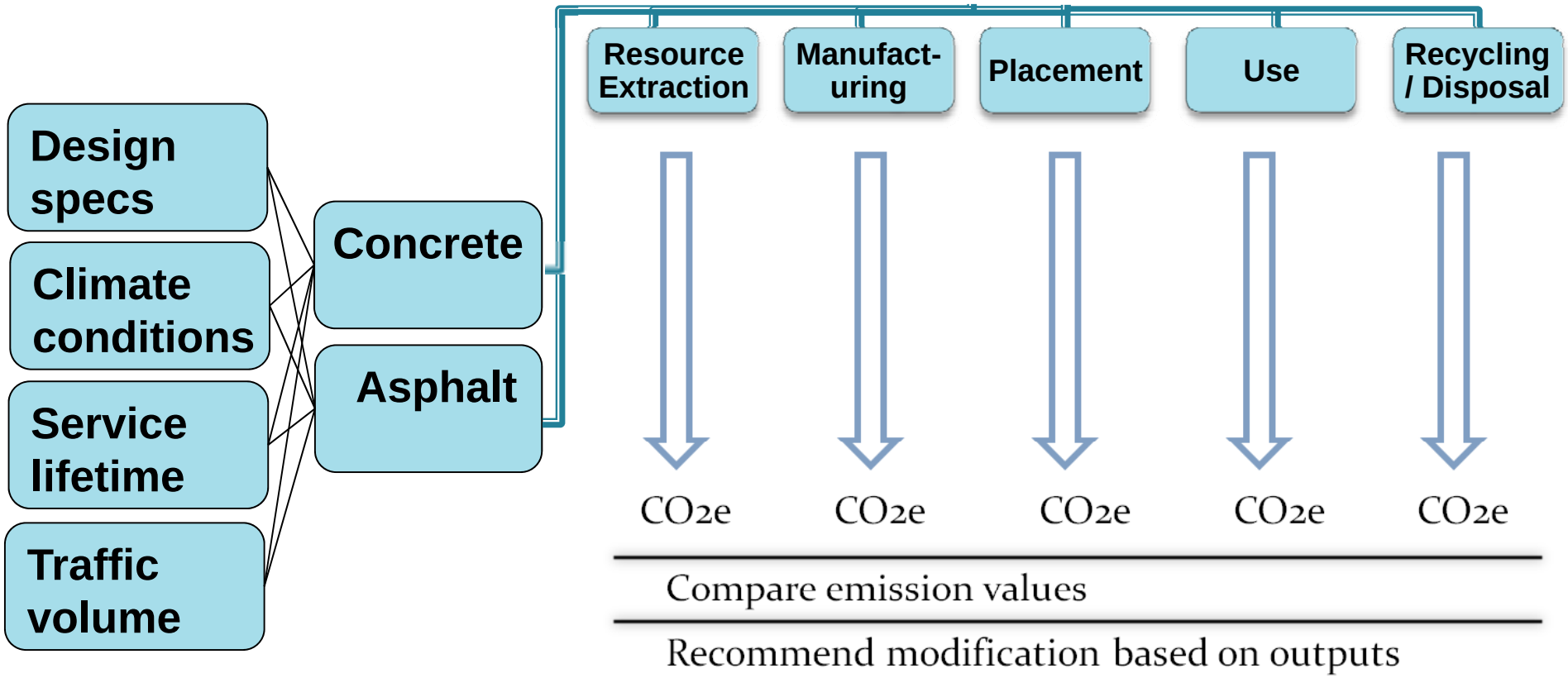
1) System boundary definition
   - All phases (above)
   - Functional unit: one lane kilometer

2) Inventory
   - Inputs – Energy and materials needs
   - Outputs – Waste and emissions

3) Impact Assessment
   - Global Warming Potential in CO_2e

4) Results interpretation

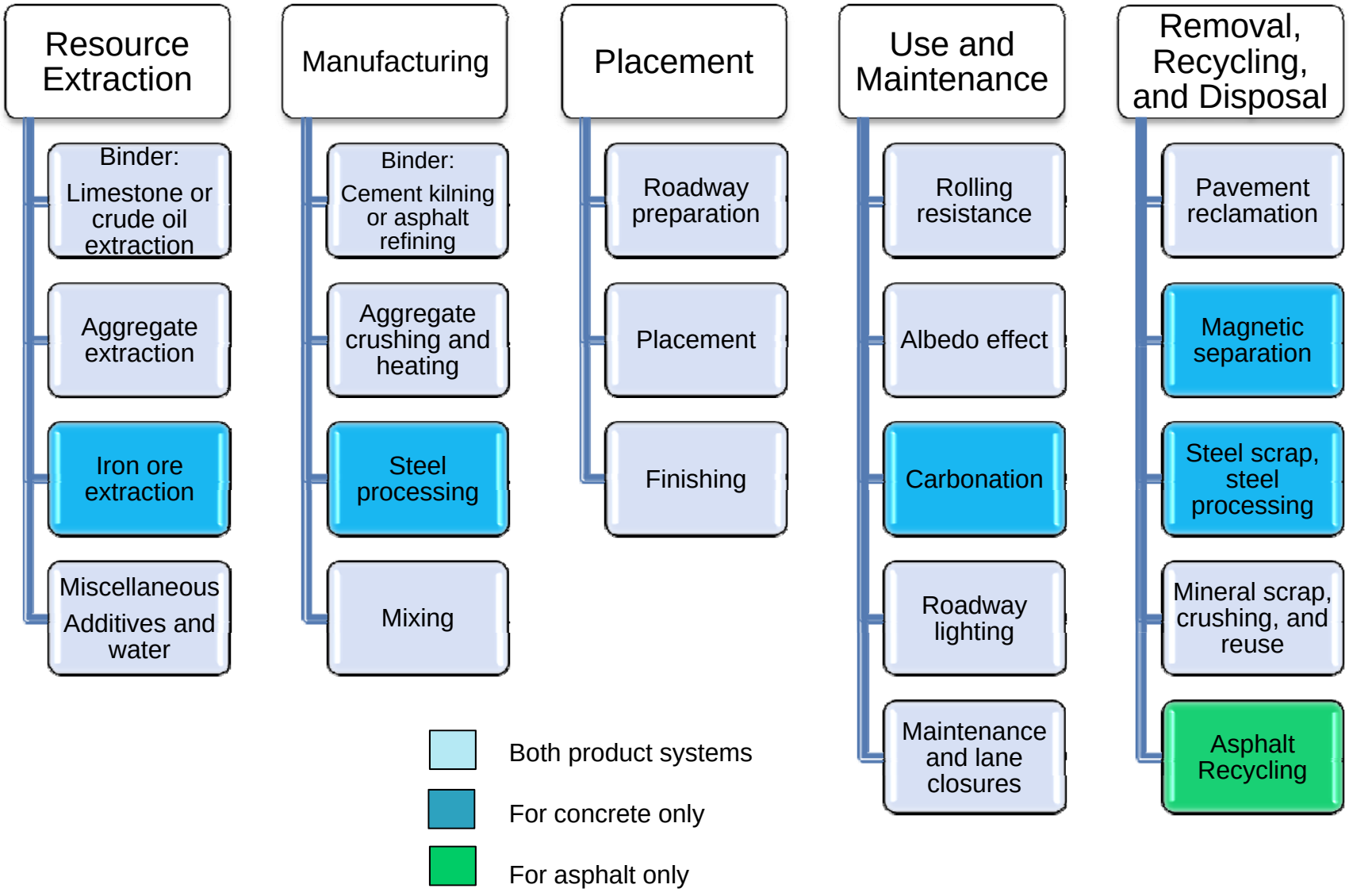
Dynamic Model



Phases and Components

Concrete vs. Asphalt

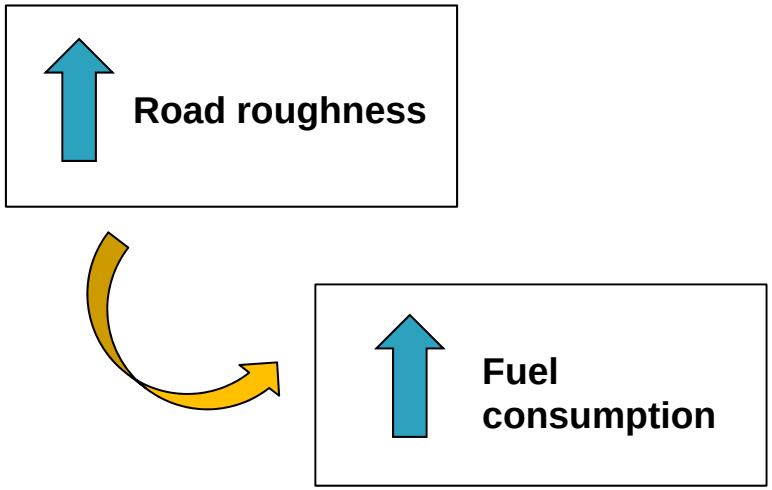
Life Cycle Phases and Subcomponents



Use Phase

Use Phase Assumptions

Account only for *increase or decrease* in emissions due to the pavement's existence



Rolling Resistance

The largest known life cycle GHG contribution

Two effects: Pavement structure and pavement roughness

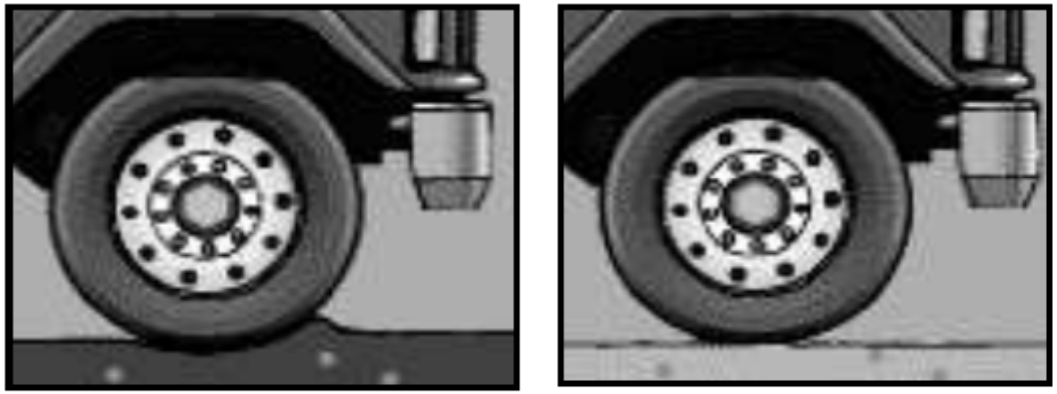


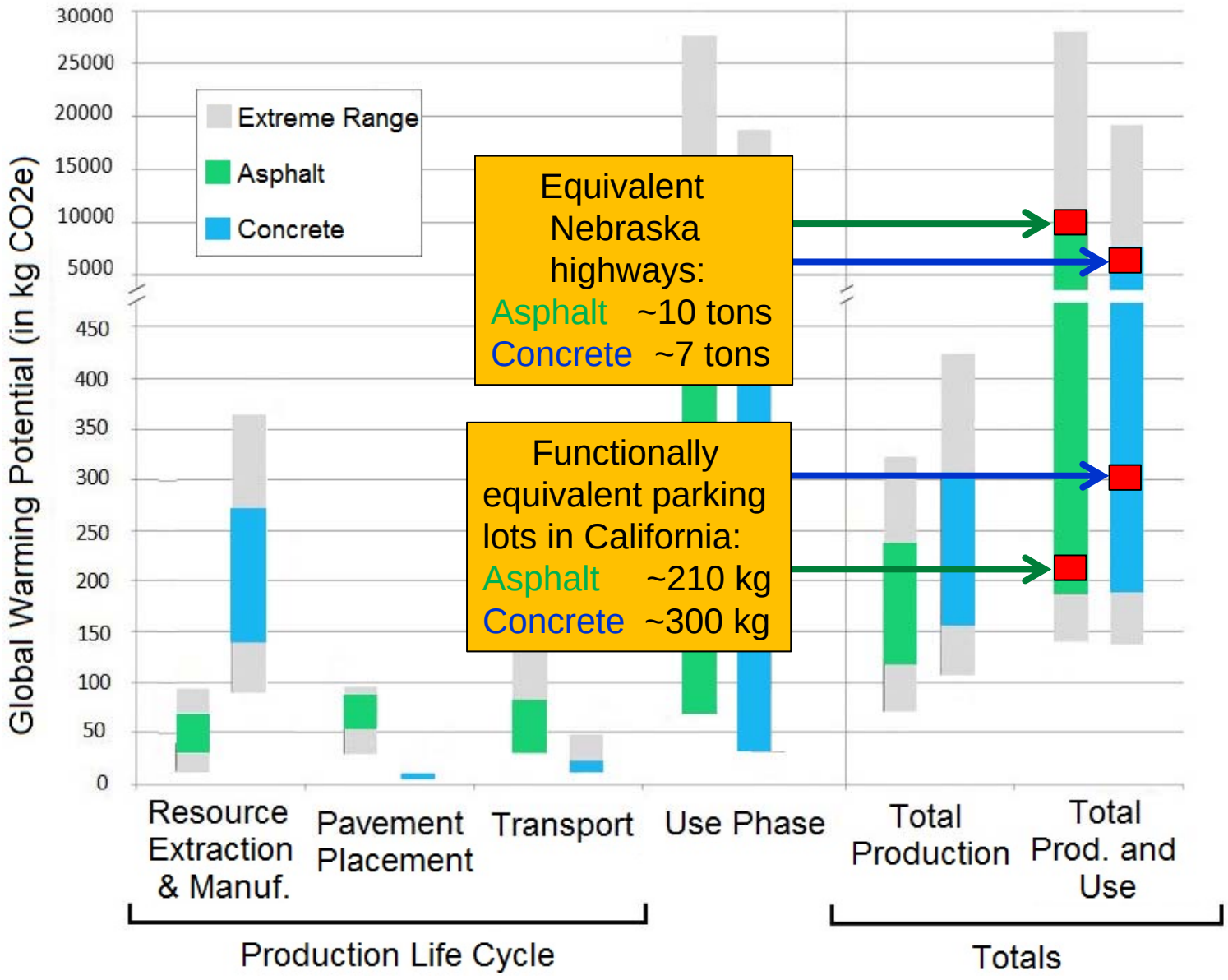
Figure 3. Illustration of asphalt (left) and concrete pavement rolling resistance

Source: Santero, et al. 2009

Parameters
Pavement type
Traffic volume
Traffic composition
Base fuel efficiency
Temperature etc.

Results

Normal Sensitivity Range

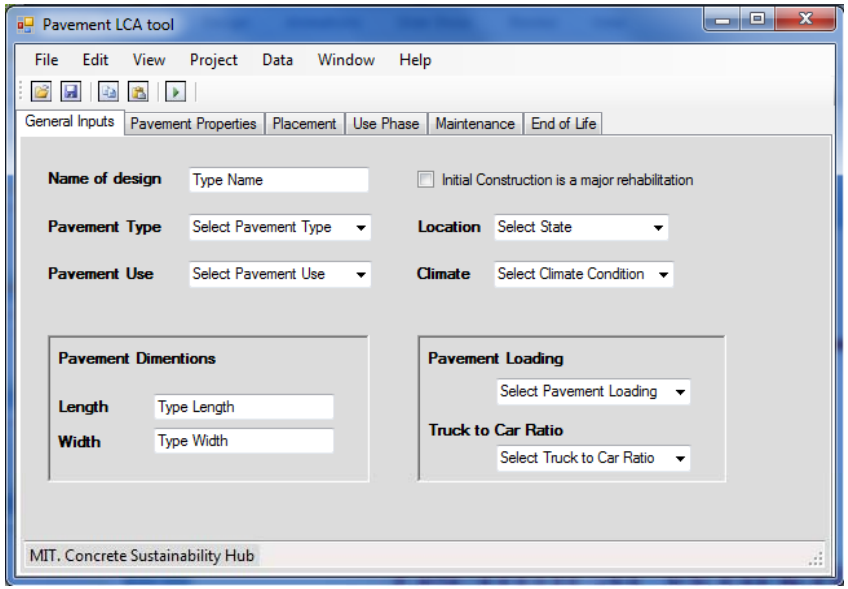


Conclusions

- **INITIAL CONDITIONS AND ASSUMPTIONS create wide variability in results of LCA—about 2 orders of magnitude.**
- There are many **OPPORTUNITIES** across the life cycle for improvement.
- The **USE PHASE** dominates under many initial conditions.
- **MAINTENANCE** is the second largest component and a trade-off with rolling resistance.

Future Work

- Improve Data Quality
- Detailed Scenario Analysis
  - 1) Decrease surface roughness by increasing preventive and rehabilitative maintenance
  - 2) Leverage albedo effect and include whitening chemicals in LCI
  - 3) Engineered Cementitious Composite (ECC), etc.
  - 4) Model fly ash, rice husk ash, etc.
- Life cycle costing
- Create tool for engineers to estimate their pavement's carbon footprint



Thank You!

Questions?

Or contact me at:
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