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LOCI

Architecture et Climat

LAB

InfraSet: Towards a Parametric Model to Quantify the Life Cycle Environmental Performance and MFA of Transport Infrastructure Assets

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THEME

*This project funded by **F.SR** and **FNRS** scholarships.*

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Faculty of Engineering Science

Pierre Latteur
UCLouvain University
Louvain School of Engineering

+50% or 700 billion

More passenger kilometre travel (PKT) demand from 2020 to 2050 In EEA and Turkey (Freight and Passenger)

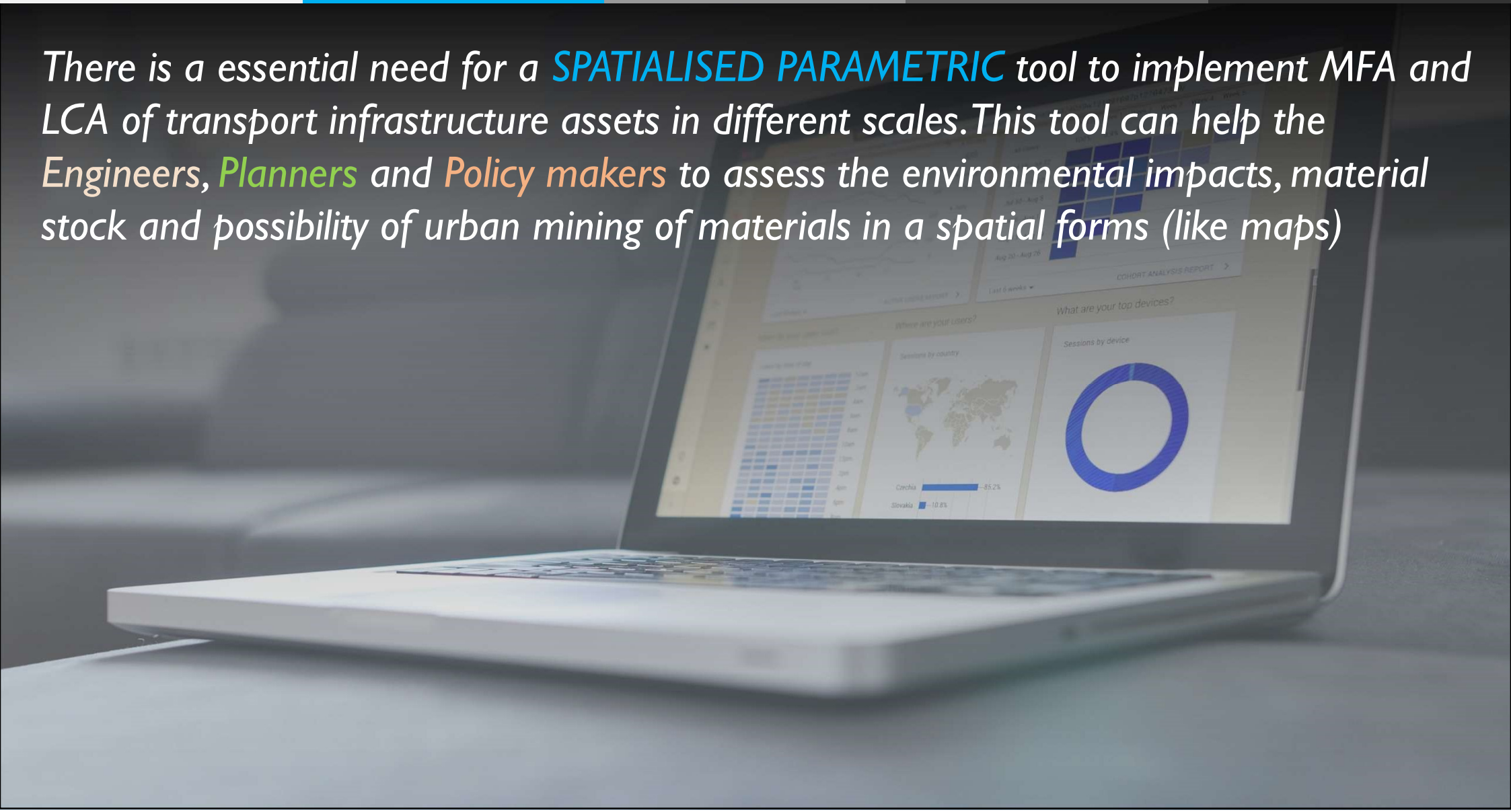
2187 tonnes CO_2eq greenhouse gas (GHG) for building one km of a road

Sightline INSTITUTE

Urban mining /MFA

has the following benefits: Less environmental impacts, Classic mining can not meet the increasing demand and for some rare materials it is the only way.

Fraunhofer



There is a essential need for a SPATIALISED PARAMETRIC tool to implement MFA and LCA of transport infrastructure assets in different scales.This tool can help the Engineers, Planners and Policy makers to assess the environmental impacts, material stock and possibility of urban mining of materials in a spatial forms (like maps)

Engineers

Assessment of different techniques and design in **element, assembly and infrastructure scales**


Engineers
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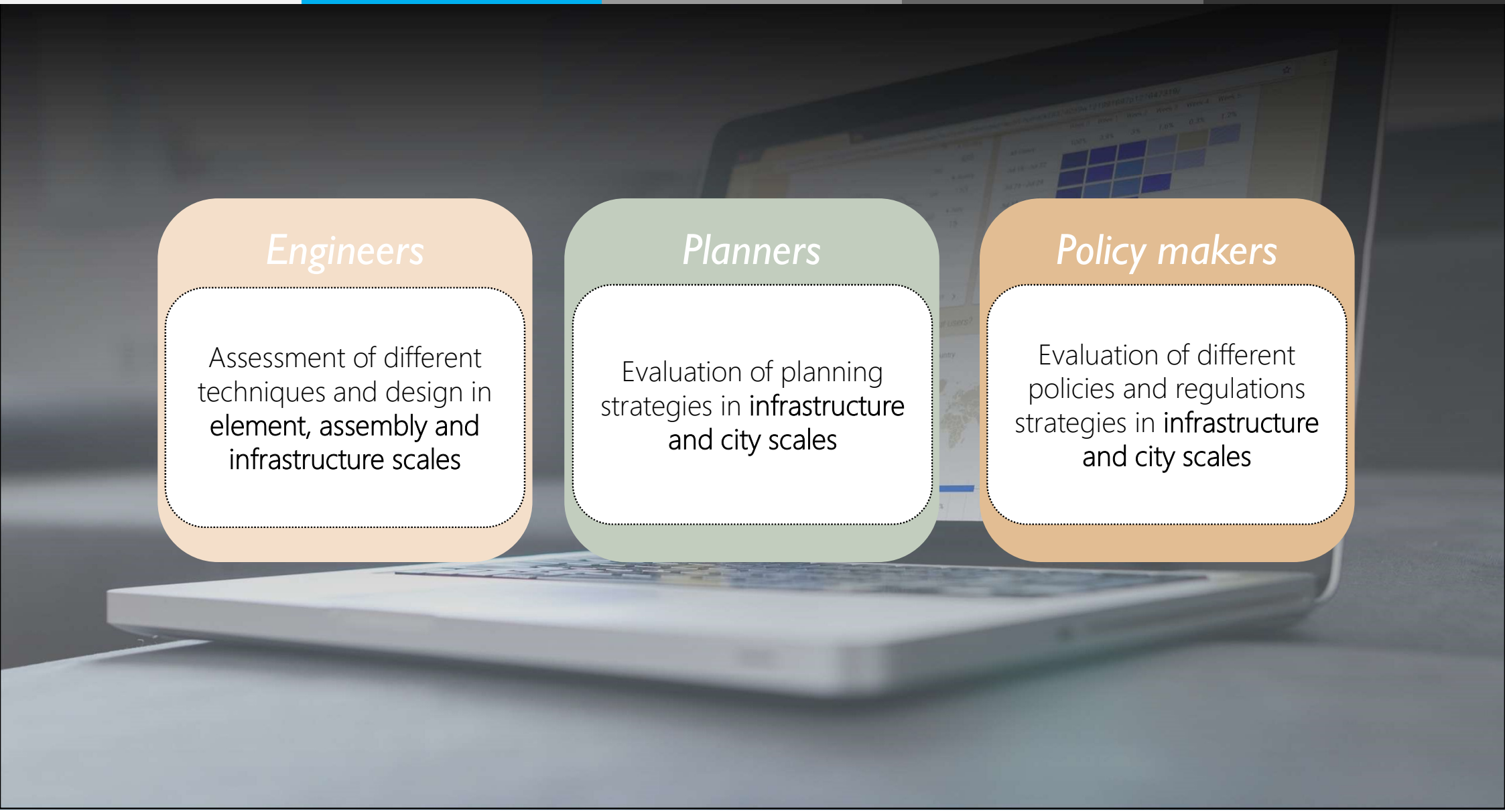
Planners
Evaluation of planning strategies in infrastructure and city scales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Evaluation of different policies and regulations strategies in **infrastructure and city scales**

reducing energy, emissions and material consumption

CIRCULARITY

circularity and urban mining

Goal and Scope

Parametrization

-Finding Parameters
-Writing equation
-Data from databases

Implementation

-Object oriented programming (OOP)
-Architecture of this model
-Graphical user interface (GUI)

Verification

-Testing the codes and model

Validation

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Transport Infrastructure Assets
- Rail
- Road

LCA and MFA indicators
- Energy
- Emission
- Mass

Energy and emission flows
- Operational
- Lighting
- Embodied

RESEARCH DESIGN

Material composition
- Literature review
- Construction technology

Environmental coefficients
- EPiC database

Geometry
- Geographical Information System (GIS)

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Case studies
- **Boulevard du Souverain**
- **Rail road case study in Belgium**
- **A road case study in Australia**

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RESEARCH DESIGN

WP4. Tool development INFRASET PLUGIN

Infraset plugin

GIS plugin

GIS data

GIS data

-Land use
-Road Class – Classifies roads (Local road, highway, ramp, roundabout, etc)
-Geometry
-Spatialised data(like maps)

EPIC plugin

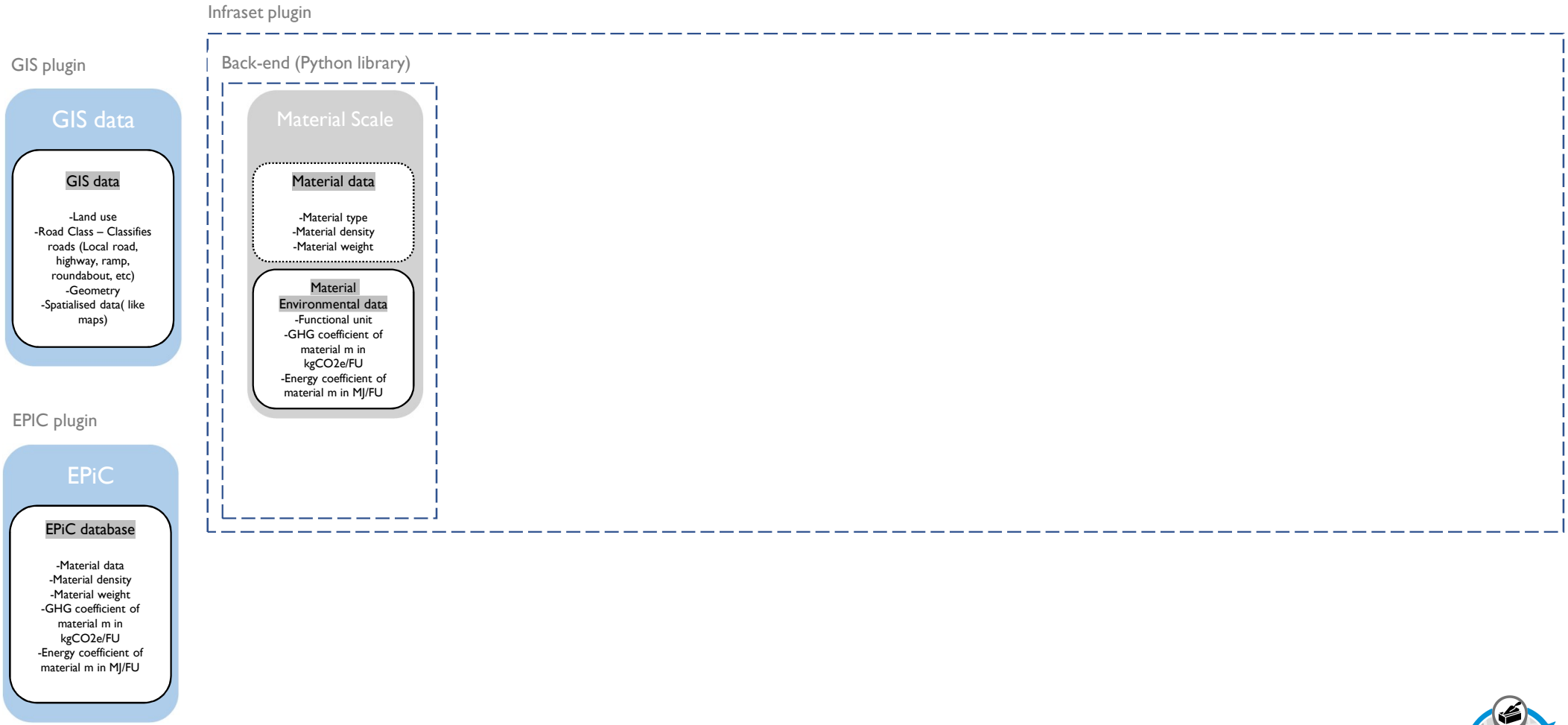
EPiC

EPiC database

-Material data
-Material density
-Material weight
-GHG coefficient of material m in kgCO2e/FU
-Energy coefficient of material m in MJ/FU

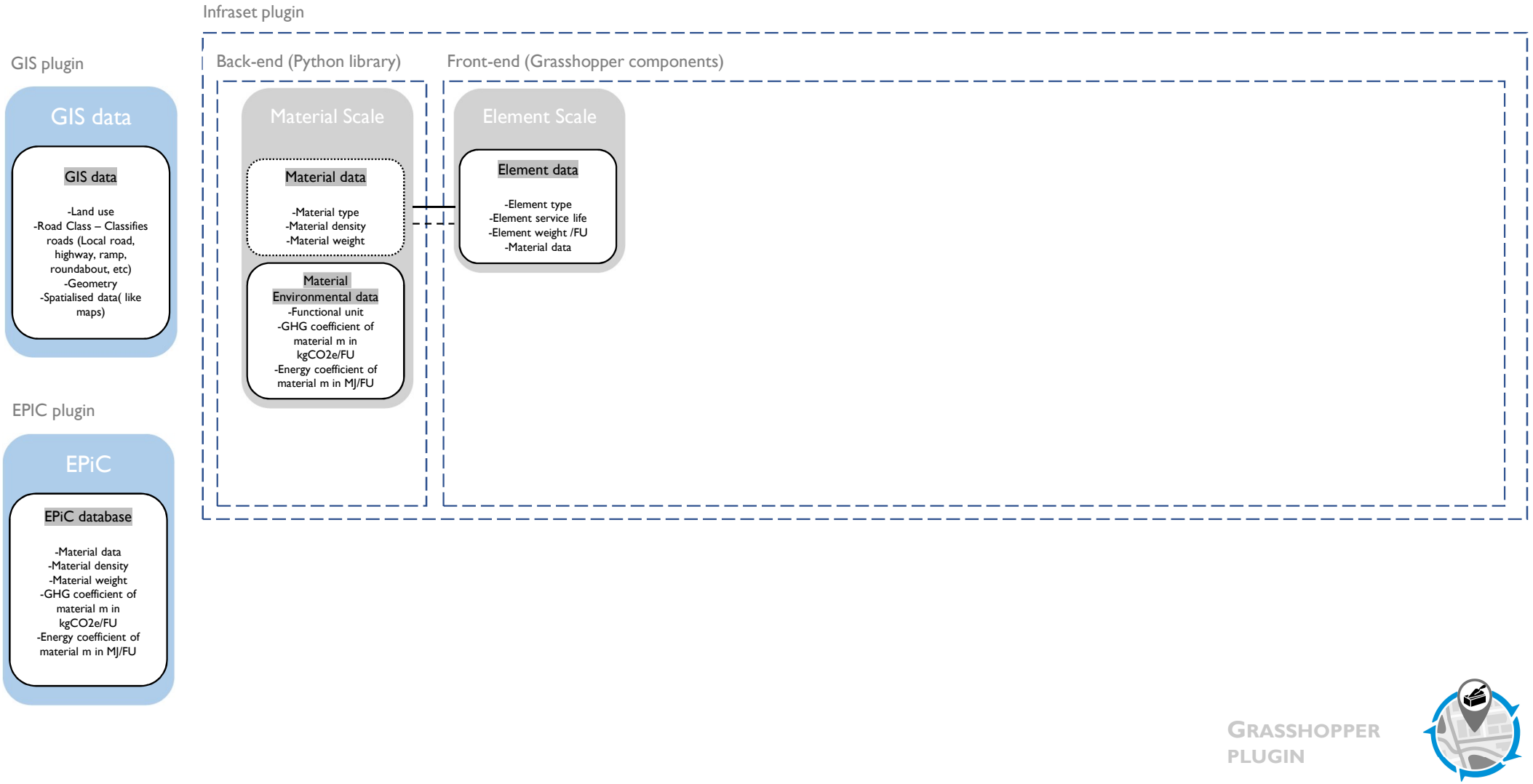
GRASSHOPPER PLUGIN

WP4. Tool development INFRASET PLUGIN

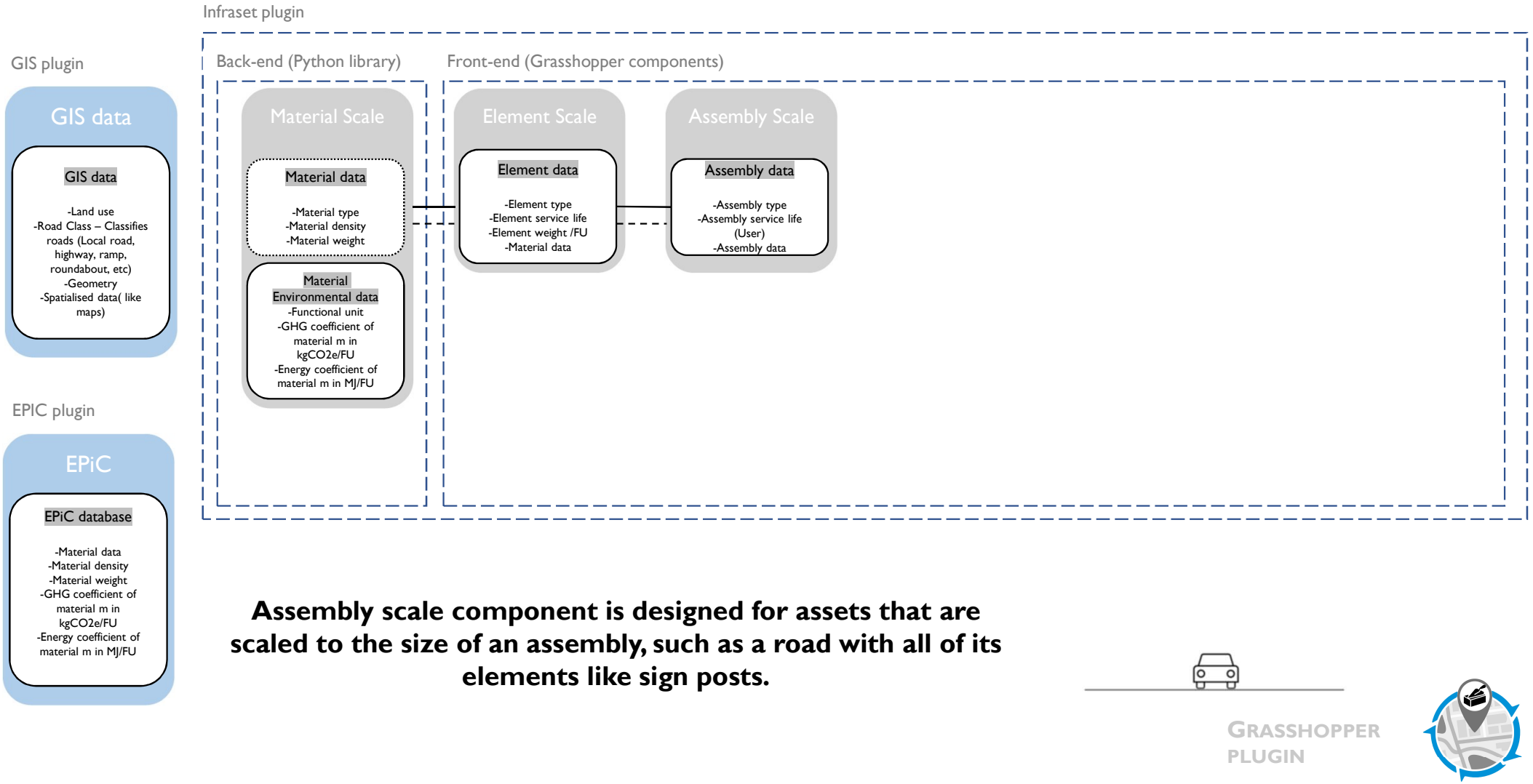


GRASSHOPPER PLUGIN

WP4. Tool development INFRASET PLUGIN



WP4. Tool development INFRASET PLUGIN



Assembly scale component is designed for assets that are scaled to the size of an assembly, such as a road with all of its elements like sign posts.

GRASSHOPPER PLUGIN

WP4. Tool development INFRASET PLUGIN

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Infraset plugin

Back-end (Python library)

Front-end (Grasshopper components)

Material Scale

Material data

-Material type
-Material density
-Material weight

Material Environmental data

-Functional unit
-GHG coefficient of material m in kgCO2e/FU
-Energy coefficient of material m in MJ/FU

Element Scale

Element data

-Element type
-Element service life
-Element weight /FU
-Material data

Assembly Scale

Assembly data

-Assembly type
-Assembly service life (User)
-Assembly data

Infrastructure scale

Infrastructure data

-TIA type (category)
-TIA service life (User)
-TIA data

TIA

-TIA type (category)
-Location
-Width
-length
-design life

Transport modes

-Transport mode type
-Average occupancy
-Max occupancy

Scenarios

-Replacement
-lighting

Infrastructure scale component is created for infrastructure that is scaled to the size of a section, like a road that includes pedestrian, metro, and automobile roads. The user can also change the section.

GRASSHOPPER PLUGIN

WP4. Tool development INFRASET PLUGIN

Infraset plugin

GIS plugin

GIS data

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Element Scale

Element data

-Element type
-Element service life
-Element weight /FU
-Material data

Assembly Scale

Assembly data

-Assembly type
-Assembly service life (User)
-Assembly data

Infrastructure scale

Infrastructure data

-TIA type (category)
-TIA service life (User)
-TIA data

TIA

-TIA type (category)
-Location
-Width
-length
-design life

Transport modes

-Transport mode type
-Average occupancy
-Max occupancy

Scenarios

-Replacement
-lighting

City scale

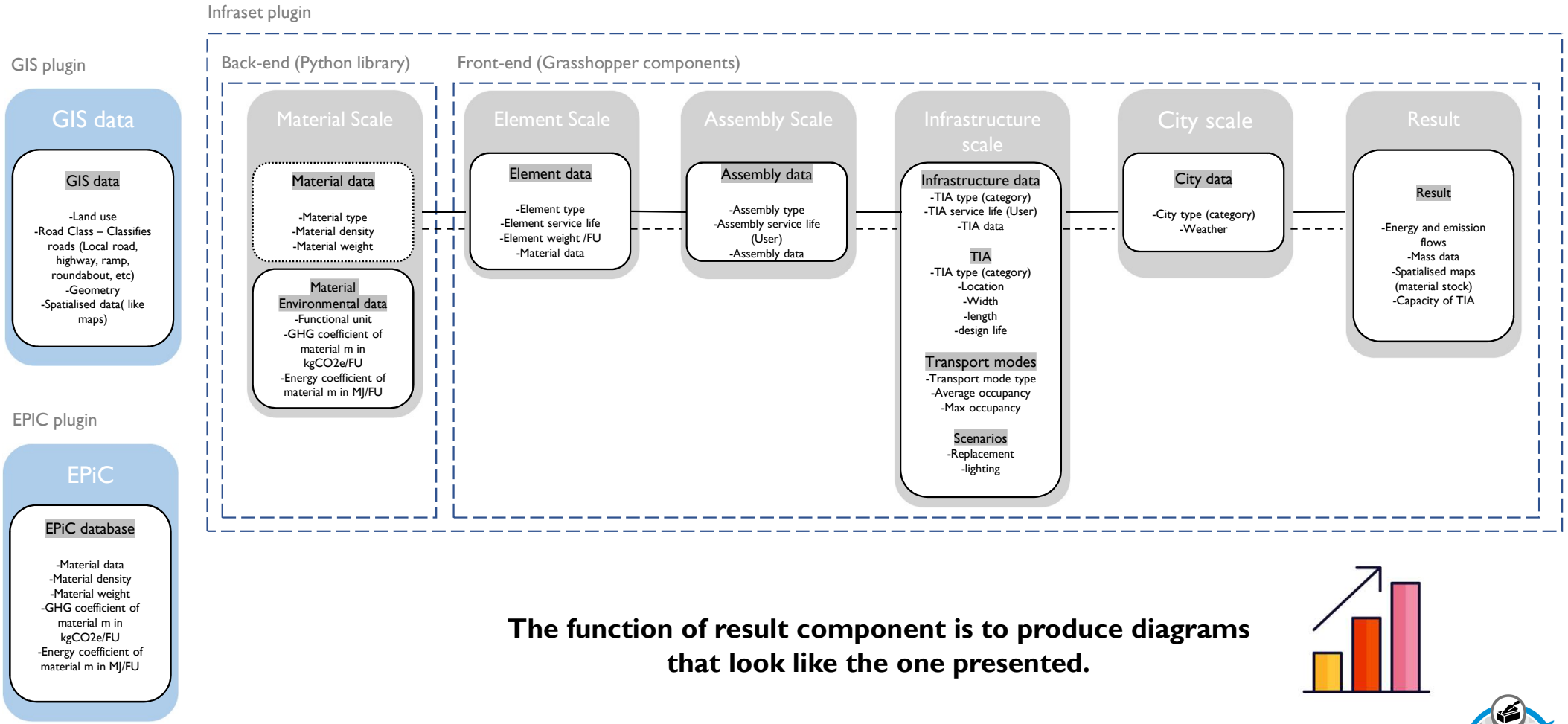
City data

-City type (category)
-Weather

City scale component enables us to analyze city-scale roads because city roads are composed of smaller scales like elements.

GRASSHOPPER PLUGIN

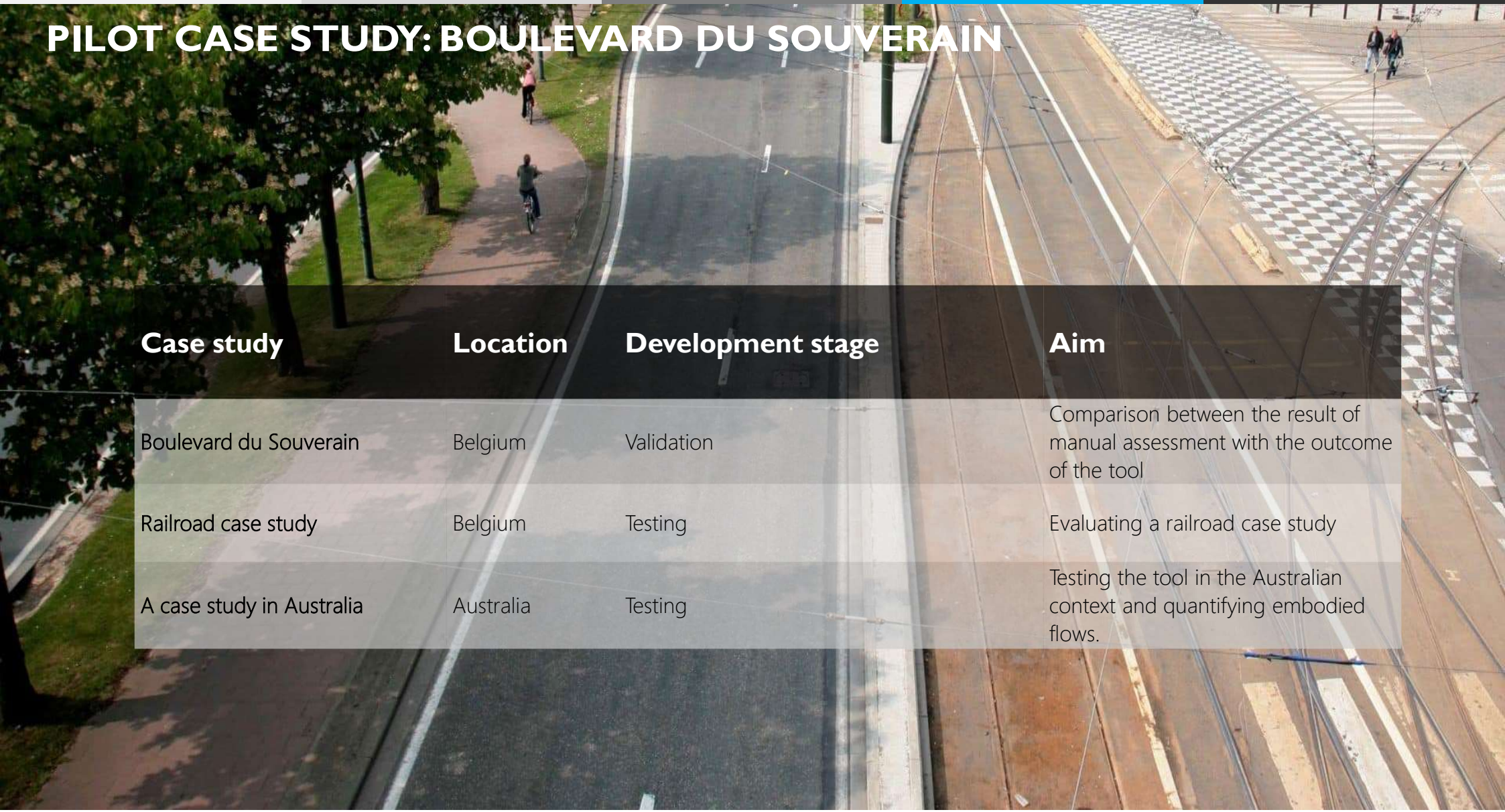
WP4. Tool development INFRASET PLUGIN



The function of result component is to produce diagrams that look like the one presented.

GRASSHOPPER PLUGIN

PILOT CASE STUDY: BOULEVARD DU SOUVERAIN



Case study	Location	Development stage	Aim
Boulevard du Souverain	Belgium	Validation	Comparison between the result of manual assessment with the outcome of the tool
Railroad case study	Belgium	Testing	Evaluating a railroad case study
A case study in Australia	Australia	Testing	Testing the tool in the Australian context and quantifying embodied flows.

QUANTITY OF ELEMENTS OR ASSEMBLIES


Bicycle stations


Tram Crossing


Tram stops


Subway stations


Sign posts


Barriers


Pedestrian crossing

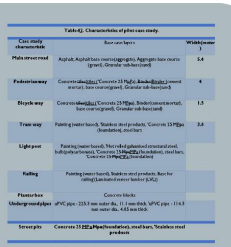


Table of the characteristics of the boulevard du souverain

MAINTENANCE


Required Painting for maintenance


Tram stops maintenance


Required Asphalt for maintenance


Rail track maintenance


Subway stations maintenance


Maintenance of light posts


Maintenance of Traffic calming

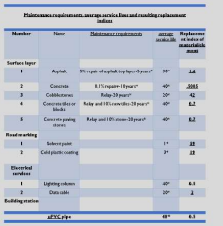


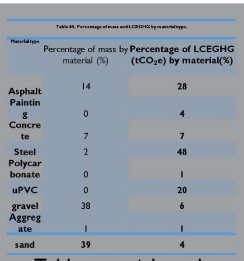
Table for maintenance requirement of different materials

MATERIAL STOCK


Steel intensity

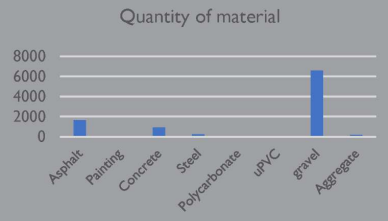

Concrete intensity


Asphalt intensity

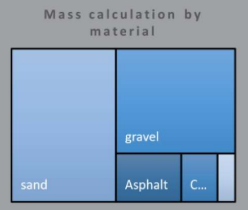


Materialtype	Percentage of mass by material (%)	Percentage of LCEGHG (tCO_2e) by material(%)
Asphalt	14	28
Painting	0	4
Concrete	7	7
Steel	2	48
Polycarbonate	0	1
uPVC	0	20
gravel	38	6
Aggregate	1	1
sand	39	4

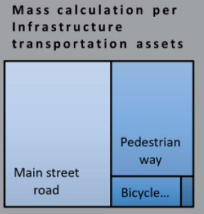
Table material stock



Bar chart of the quantity of the material



Tree map Per Material types



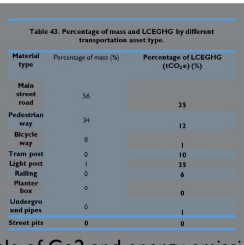
Tree map per TIA

ENVIRONMENTAL IMPACT ASSESSMENT


Total Co2 emission intensity

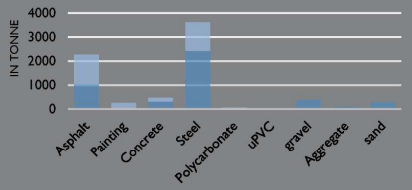

Total Energy intensity


Total water intensity

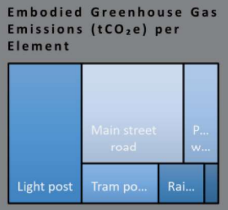


Material type	Percentage of mass (%)	Percentage of LCEGHG (tCO_2e) (%)
Main street road	56	35
Pedestrian way	34	12
Bicycle way	8	1
Tram post	0	10
Light post	1	35
Railing	0	6
Planter box	0	0
Underground pipes	0	1
Street pits	0	0

Table of Co2 and energy emission

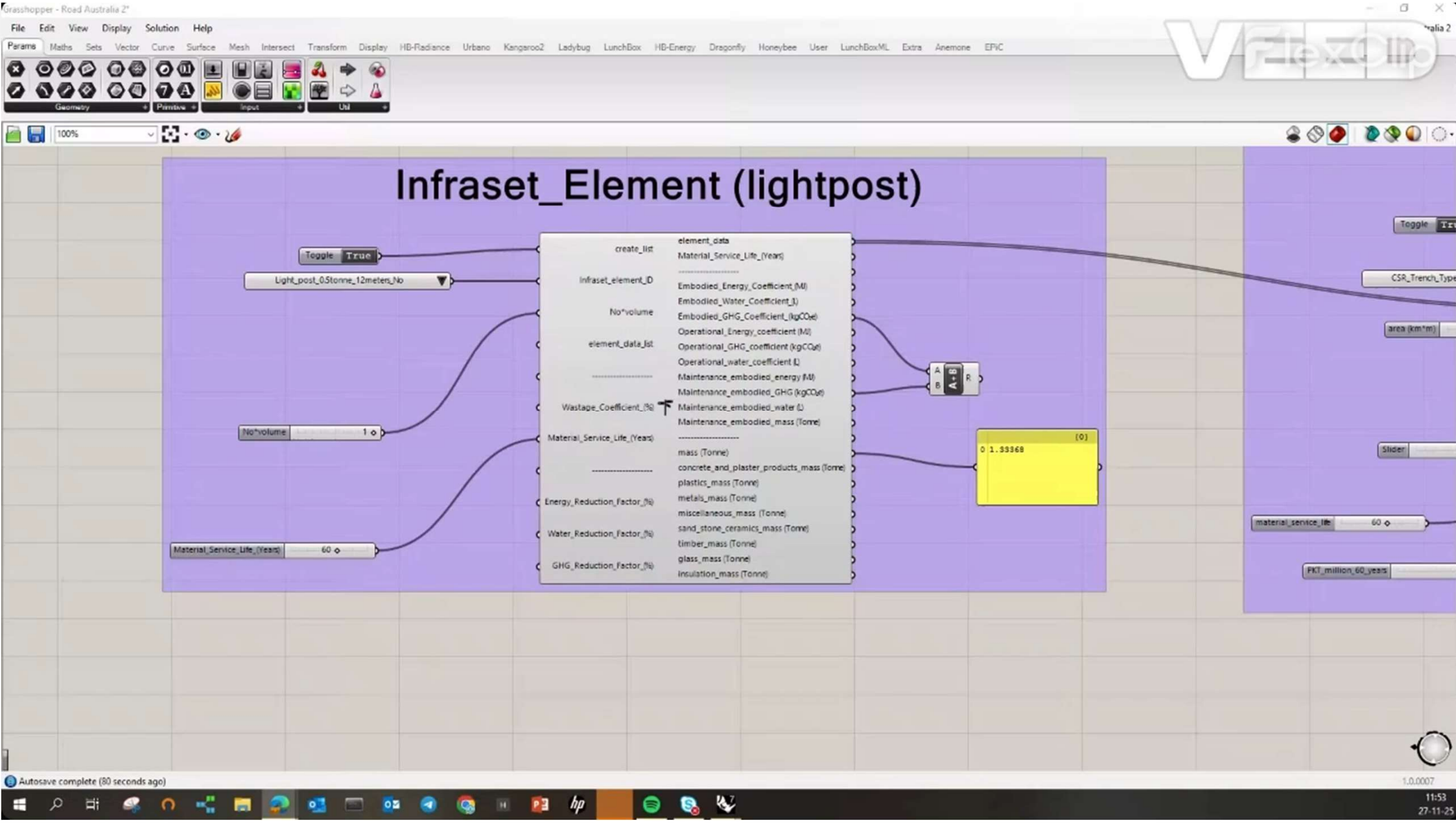


Bar chart for the Embodied and operational Energy intensity



Tree map GHG per element

Tree map GHG by material


Grasshopper - Road Australia 2*
File Edit View Display Solution Help
Params Maths Sets Vector Curve Surface Mesh Intersect Transform Display HB-Radiance Urbano Kangaroo2 Ladybug LunchBox HB-Energy Dragonfly Honeybee User LunchBoxML Extra Anemone EPiC
Geometry Primitive Input Util
100%
Infraset_Element (lightpost)
Toggle True
Light_post_0.5tonne_12meters_No
No*volume
1
Material_Service_Life_(Years)
60
create_list
Infraset_element_ID
No*volume
element_data_list
Wastage_Coefficient_(%)
Material_Service_Life_(Years)
Energy_Reduction_Factor_(%)
Water_Reduction_Factor_(%)
GHG_Reduction_Factor_(%)
element_data
Material_Service_Life_(Years)
Embodied_Energy_Coefficient_(MJ)
Embodied_Water_Coefficient_(L)
Embodied_GHG_Coefficient_(kgCO2e)
Operational_Energy_coefficient (MJ)
Operational_GHG_coefficient (kgCO2e)
Operational_water_coefficient (L)
Maintenance_embodied_energy (MJ)
Maintenance_embodied_GHG (kgCO2e)
Maintenance_embodied_water (L)
Maintenance_embodied_mass (Tonne)
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concrete_and_plaster_products_mass (Tonne)
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insulation_mass (Tonne)
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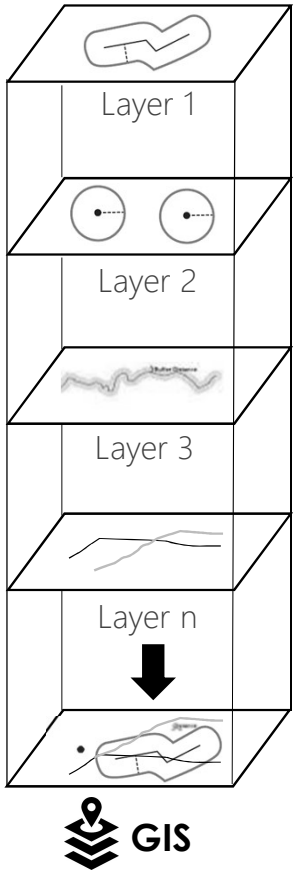
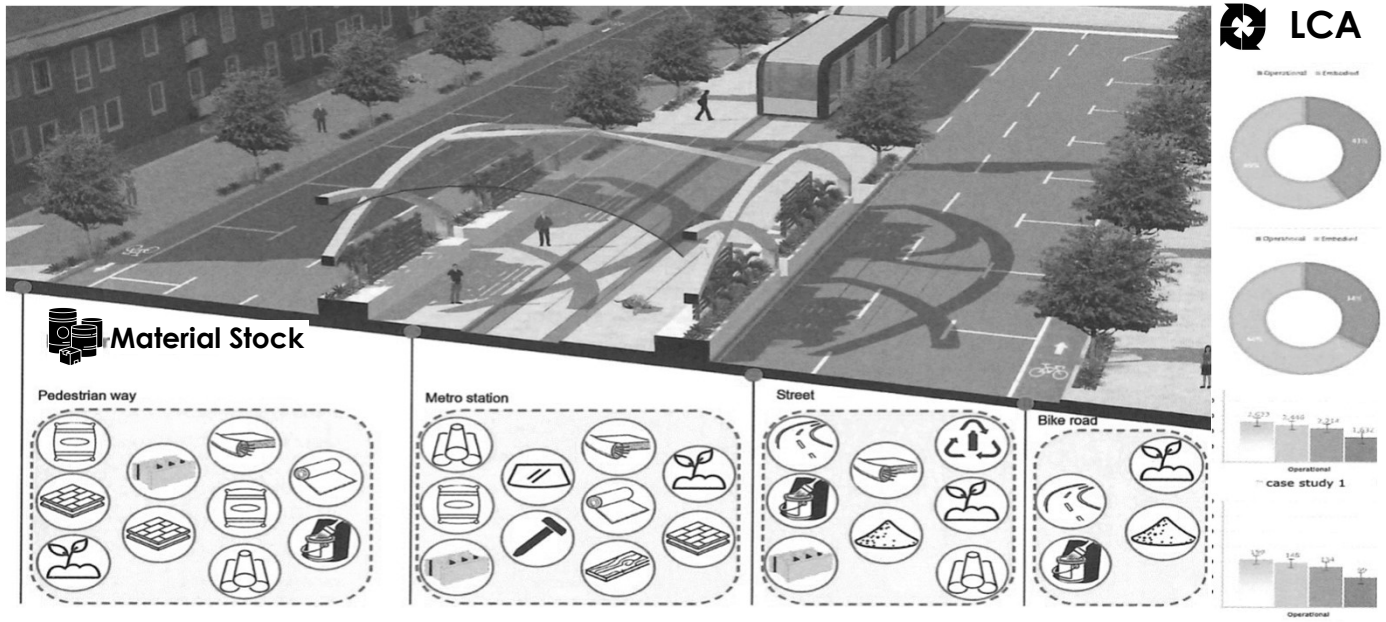
Toggle
CSR_Trench_Type
area (km*m)
Slider
material_service_life
60
PKT_million_60_years
Autosave complete (80 seconds ago)
1.0.0007
11:53
27-11-25

Thank you

Soroosh Ataee

PhD Candidate at UCLouvain





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