CALCULATION METHOD OF STOCKPILING AND USE PHASE IN ROAD LCA: CASE STUDY OF STEEL SLAG RECYCLING

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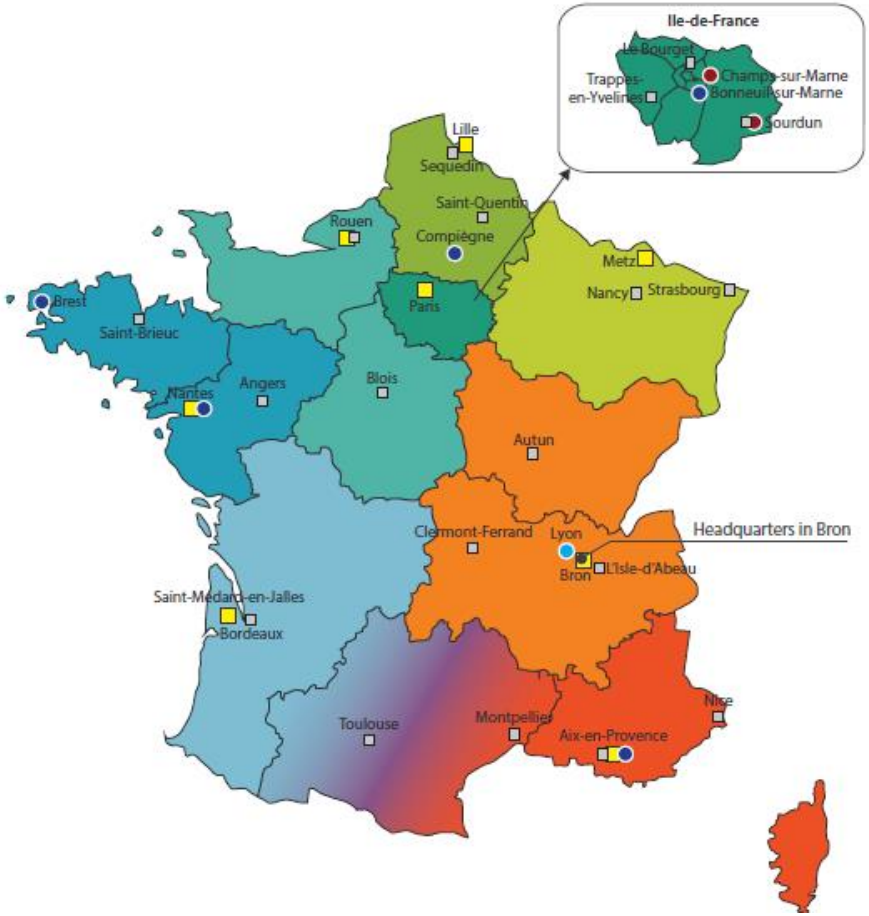
Pavement Life-Cycle Assessment, Champaign, Illinois, 12-13 April, 2017

IFSTTAR Cerema



NINE FIELDS OF OPERATION:

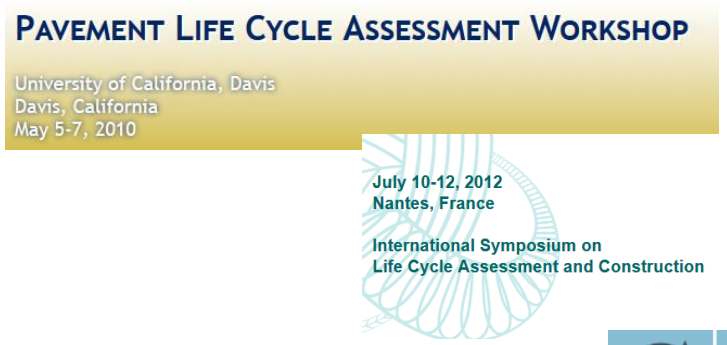
- PLANNING, DEVELOPMENT AND EQUALITY OF REGIONS
- WELL-BEING AND REDUCING POLLUTIONS
- TOWNS AND URBAN STRATEGIES
- MOBILITY AND TRANSPORTATION
- ENERGY TRANSITION AND CLIMATE CHANGE
- MANAGEMENT, OPTIMIZATION, MODERNIZATION AND DESIGN OF INFRASTRUCTURES
- MANAGEMENT OF NATURAL RESOURCES AND THE ENVIRONMENT
- HOUSING AND BUILDINGS
- RISK PREVENTION

OUR ACTIVITIES

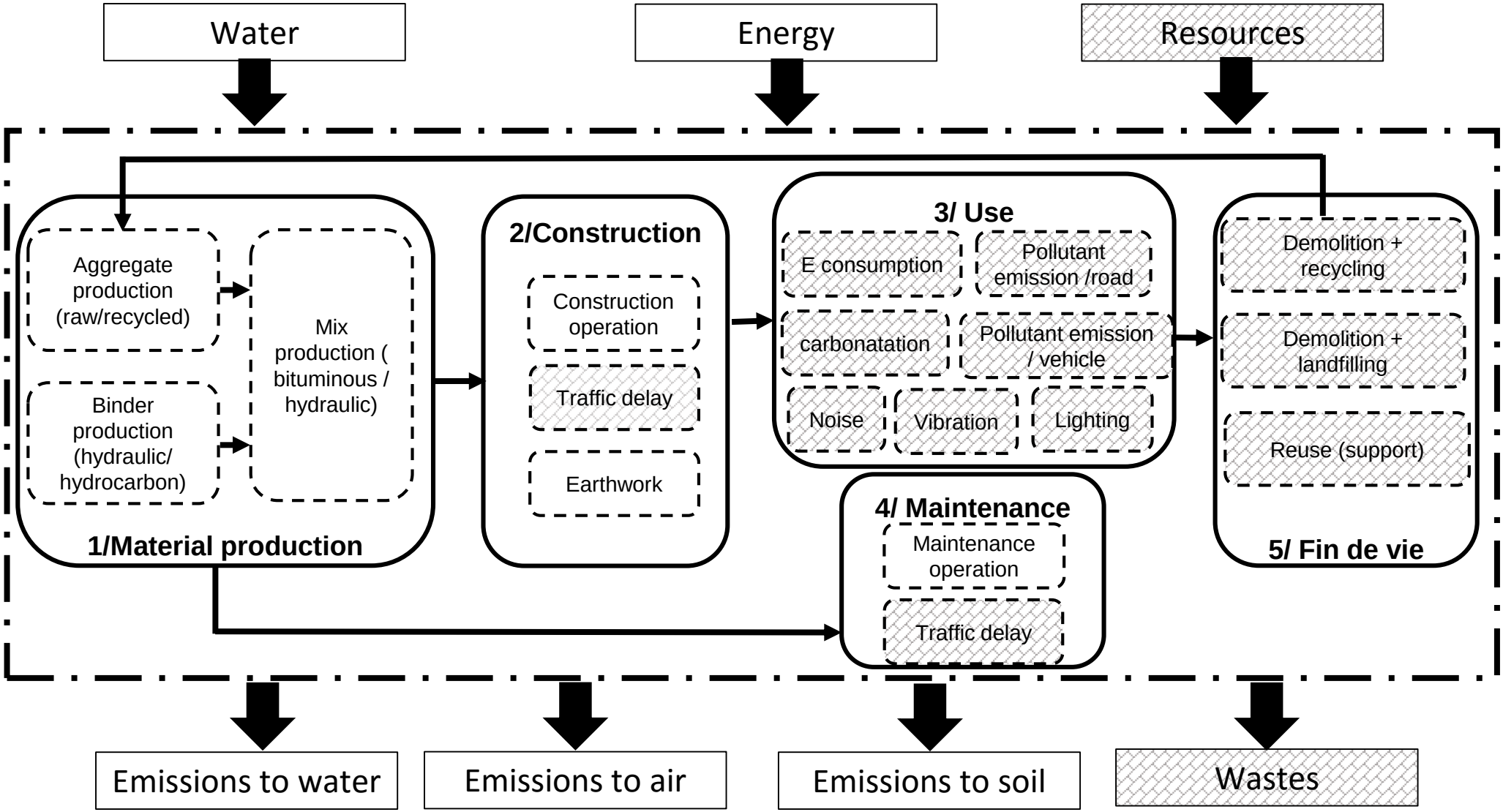
- Innovation and Research
- Methodology and assistance to contracting authorities
- Knowledge and know-how capitalisation
- Knowledge dissemination
- Technical studies and territories observation
- Standardisation and certification
- Engineering

Great interest in LCA applied to pavements…

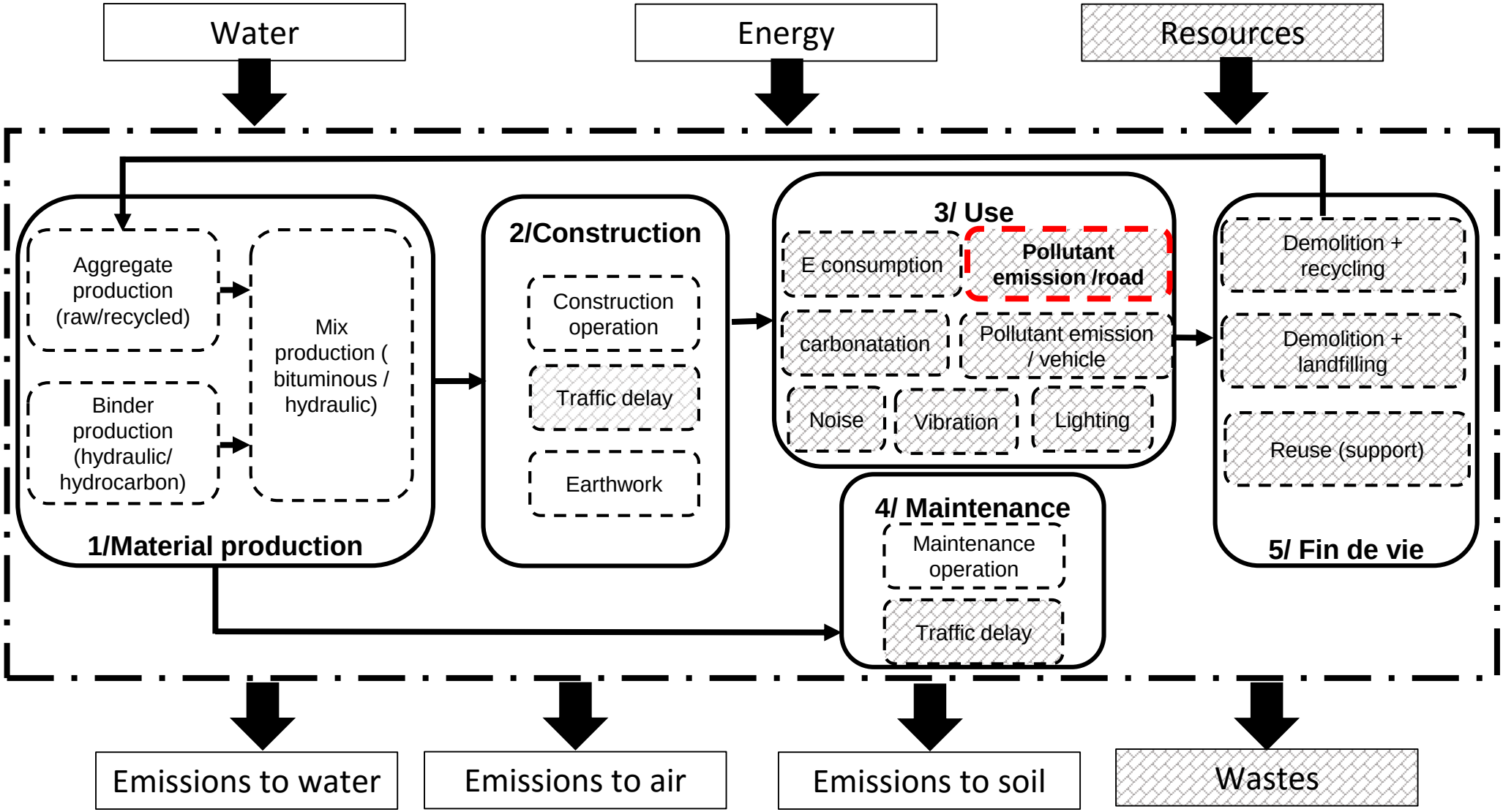
- **Hundred of papers**
- **Symposium and workshops**



…but


Water
Energy
Resources
Aggregate production (raw/recycled)
Binder production (hydraulic/ hydrocarbon)
Mix production (bituminous / hydraulic)
1/Material production
2/Construction
Construction operation
Traffic delay
Earthwork
3/ Use
E consumption
Pollutant emission /road
carbonatation
Pollutant emission / vehicle
Noise
Vibration
Lighting
4/ Maintenance
Maintenance operation
Traffic delay
Demolition + recycling
Demolition + landfilling
Reuse (support)
5/ Fin de vie
Emissions to water
Emissions to air
Emissions to soil
Wastes

…but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Wastes

When alternative materials are used

⇒ Only primary and secondary production are considered in P LCA

⇒**Stockpiling impact =0**

⇒ **Use impact = 0**

BUT Wastes release substances into water

Objective:

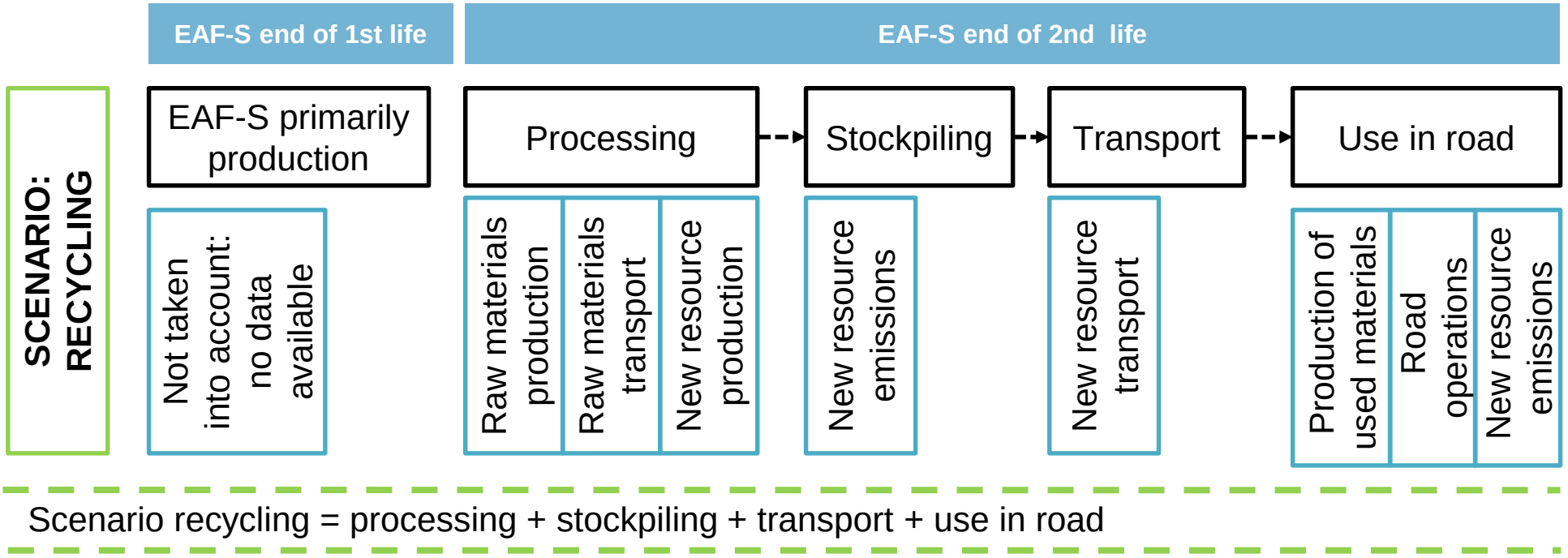
New approach of environmental impact assessment of recycling waste (EAF-S)

⇒ considering release of chemical substances from the waste to water
⇒ Ecotoxic Potential and Toxic Potential

For

⇒ Stockpiling phase
⇒ Use phase

Method: The scenario and processes investigated in this study



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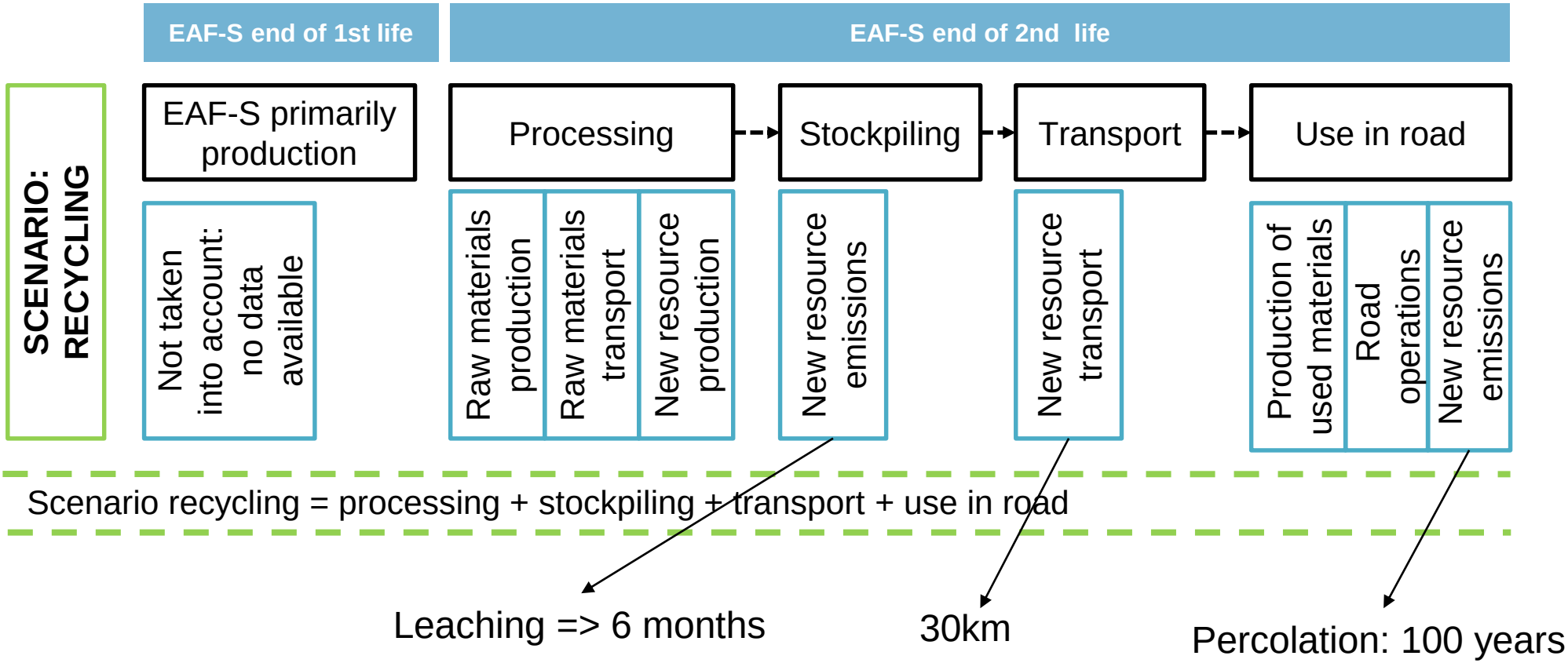


❖ the structure simulated is a non-covered 10-15 cm thick road layer of EAF-S

Method: calculation

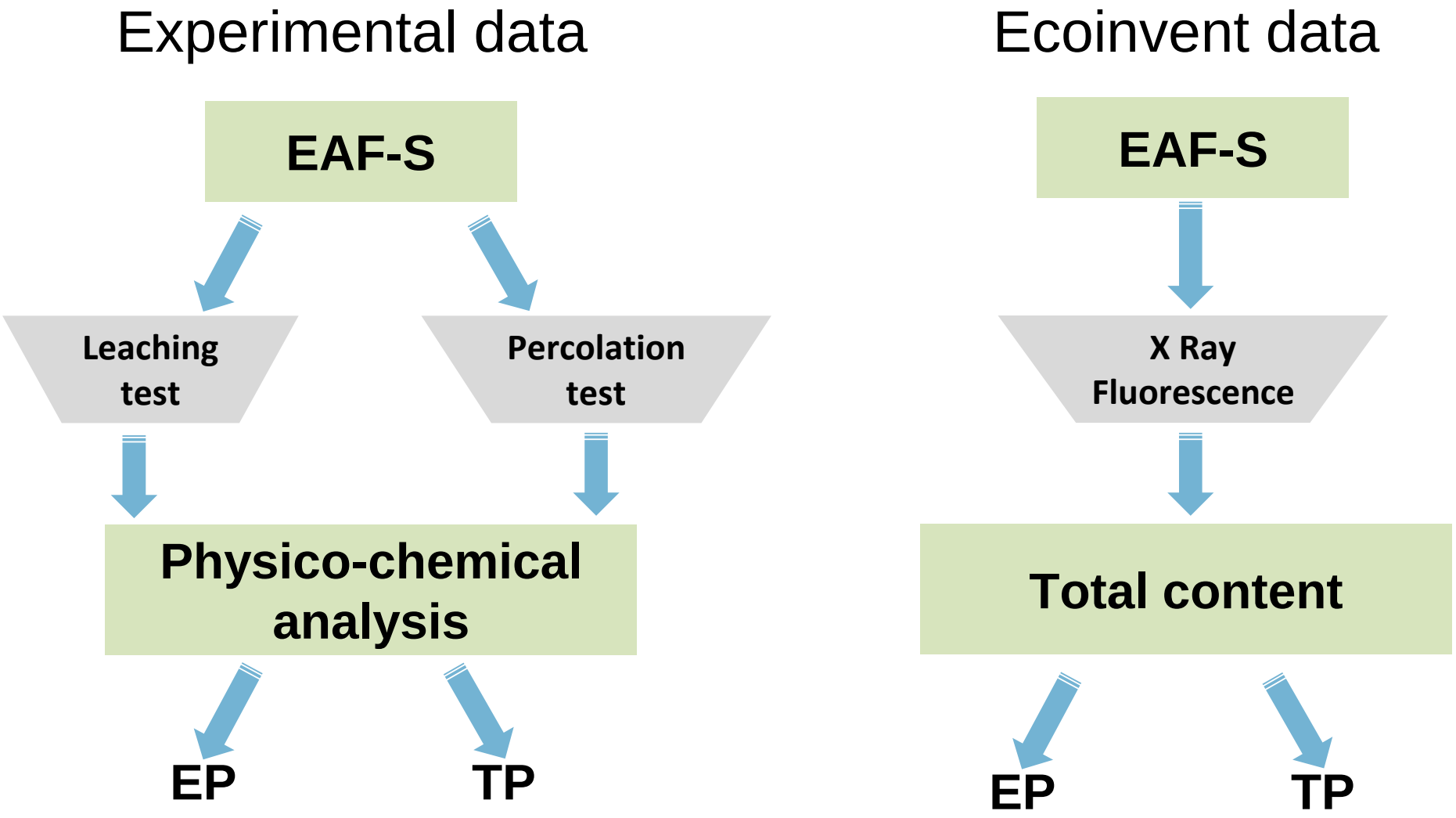
The calculation of impact indicators, is described as:

$$Ind\ j = \Sigma i\ \alpha i\ j \times Ci\ j \times mi$$

Ind j, indicator associated with impact category j; mi, mass of inventory flow i (kg); Cij, contribution coefficient of inventory flow i to impact category j; and αij: classification coefficient (from Goedkoop, 2001).

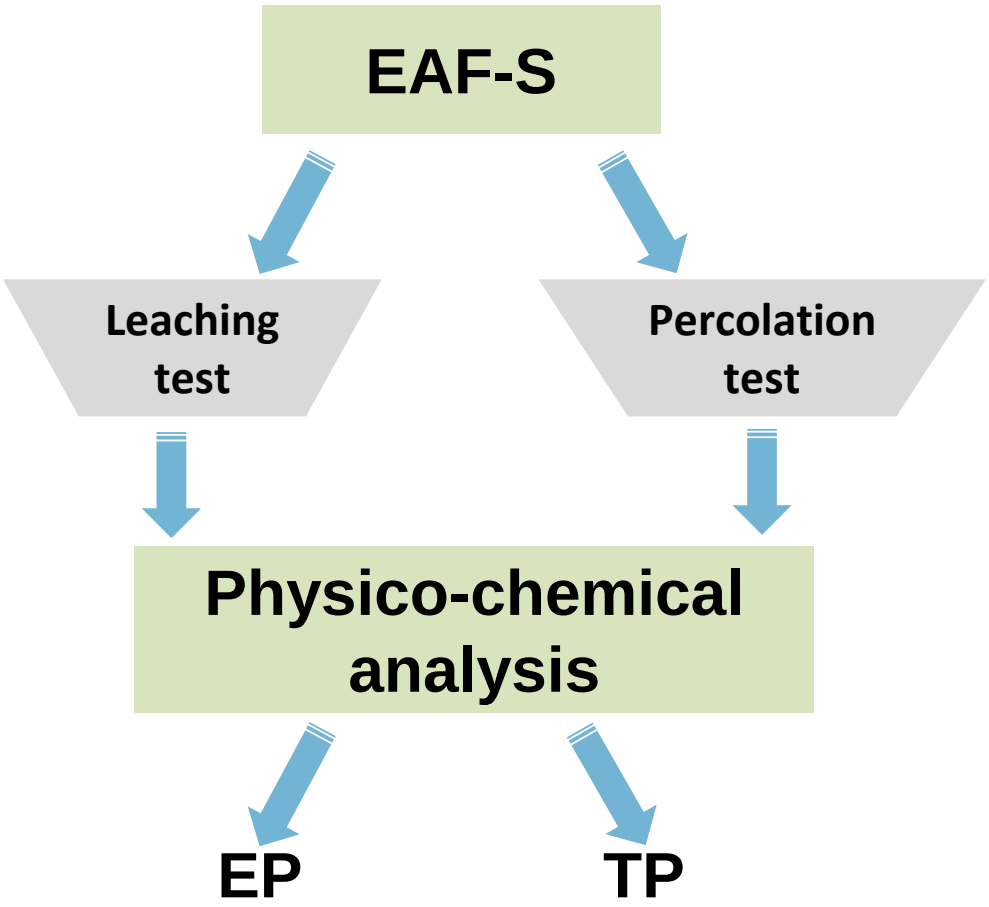
⇒ **E (MJ),**
⇒ **GWP (kg Eq CO_2),**
⇒ **EP (kg Eq 1,4 DCB), TP (kg Eq 1,4 DCB)**
http://ecorcem.ifsttar.fr, reference manual (Cerema, Ifsttar)

Method: 2 calculation methods for EP and TP

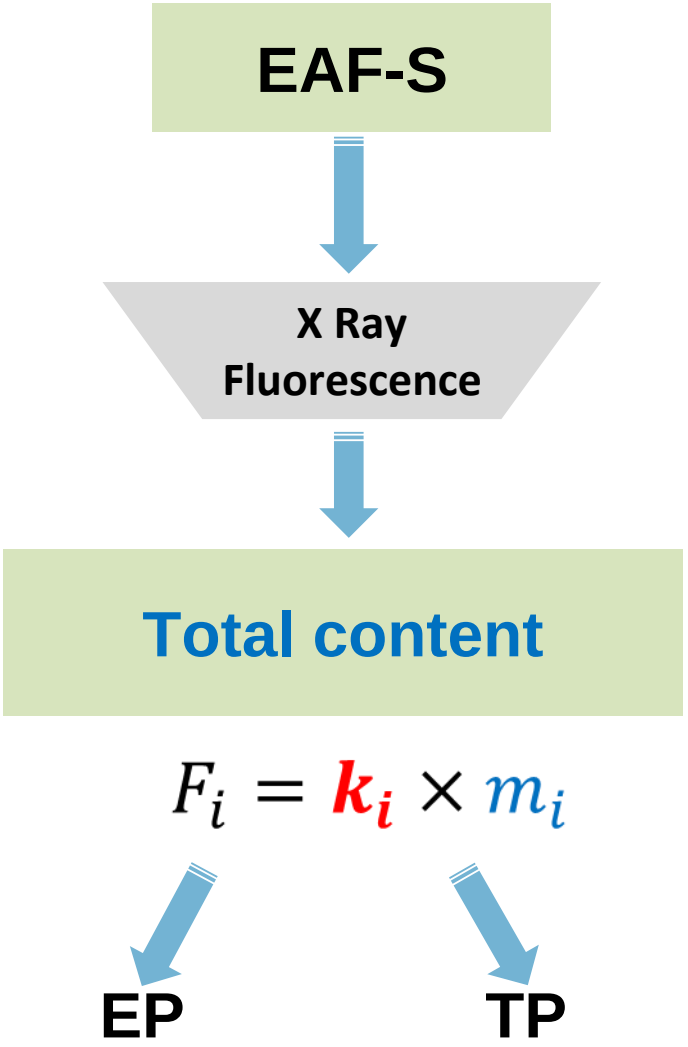


Method:

Experimental data



Ecoinvent data



Material: Raw and processed EAF-S

Physical properties of raw EAF-S

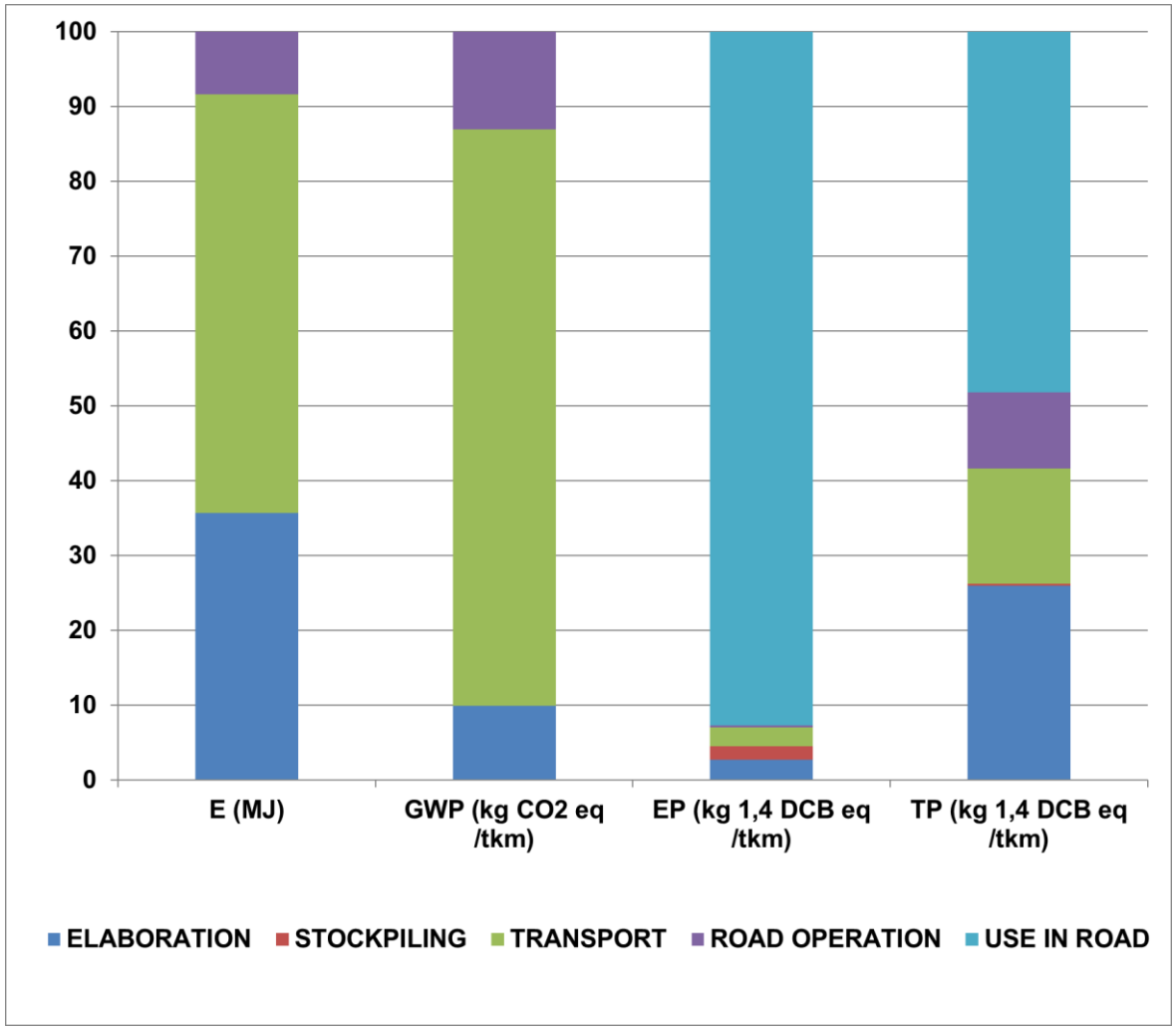
Properties	**EAF-S**
Real bulk density (t/m^3)	2.5
Natural water content (Wnat%)	18
Blaine specific surface area (cm^2/g)	5790
Gap-grading analysis	0/1mm

Chemical composition of raw EAF-S and processed EAF-S

Elements	Units	Raw EAF-S	Processed EAF-S
Silicon dioxide (SiO_2)	% by weight	32.9	ND
Titanium dioxide (TiO_2)	% by weight	0.4	ND
Aluminium oxide (Al_2O_3)	% by weight	8.1	ND
Iron oxide (Fe_2O_3)	% by weight	14.1	ND
Manganese oxide (MnO)	% by weight	1.5	ND
Magnesium oxide (MgO)	% by weight	3.9	ND
Calcium oxide (CaO)	% by weight	15.8	ND
Sodium oxide (Na_2O)	% by weight	0.2	ND
Potassium oxide (K_2O)	% by weight	0.8	ND
P_2O_5	% by weight	0.2	ND
Arsenic (As)	mg/kg	<100	42
Cobalt (Co)	mg/kg	275	0
Chromium (Cr)	mg/kg	18000	10706
Copper (Cu)	mg/kg	1040	208
Molybdenum (Mo)	mg/kg	589	502
Nickel (Ni)	mg/kg	1510	849
Vanadium (V)	mg/kg	426	228
Zinc (Zn)	mg/kg	399	205
Zircon (Zr)	mg/kg	1350	ND

ND: not determined

Results: Contribution of each life cycle phase of recycling EAF-S in road

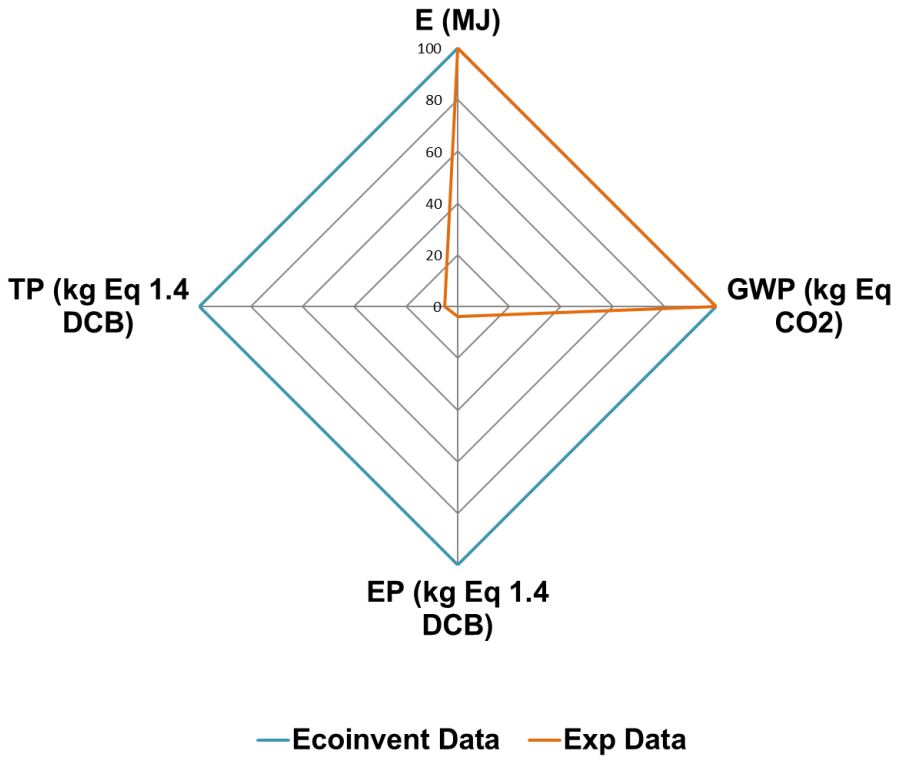


⇒ Transport is the main contributor to E and GWP

⇒ Use phase is the main contributor to EP and TP

⇒ the contribution of Stockpiling phase is insignificant

Results: LCA calculation using Expr data vs. Eco invent data



	Exp Data	Ecoinvent Da
E (MJ)	96,47	96,47
GWP (kg Eq CO2)	4,05	4,05
EP (kg Eq 1.4 DCB)	99,125	2697,225
TP (kg Eq 1.4 DCB)	3,0481	62,0781

⇒ EP, TP calculated with Ecoinvent data >>> Expr data

Results: LCA calculation using Expr data vs. Eco invent data

- transfer coef of As and Mo (100y) = 1

⇒ **Calculation with Ecoinvent** data suppose that the total content is transferred

- Total content Mo> As

⇒ EP, TP seem to be driven by Mo content when calculated with Ecoinvent data

Results: LCA calculation using Expr data vs. Eco invent data

Results of processed EAF-S percolation test (L/S=10)

Elements	EAF-S after processing (kg/kg)
Arsenic (As)	8.63E-10
Baryum (Ba)	1.71E-05
Cadmium (Cd)	2.17E-11
Chromium (total)	4.30E-06
Copper (Cu)	2.45E-08
Molybdenum (Mo)	9.94E-06
Nickel (Ni)	ND
Lead (Pb)	3.19E-08
Antimony (Sb)	3.41E-07
Selenium (Se)	4.16E-08
Vanadium	ND
Zinc (Zn)	1.03E-08

- EAF-S Mo content =0.5E-03kg/kg

⇒ All Mo is not transferred!

⇒ Diffusion from its bearing phases (iron silicate and melilite) is very low in demineralized water (Chebbi et al. 2016)

⇒ Calculation using the Ecoinvent database appears to overestimate EP, TP

⇒But studies of EAF-S percolation in solutions, with pH values close to the field, should be made to confirm this observation.

Conclusions:

On the basis of LCA study

- The impacts of the life cycle phases corresponding to stockpiling and use of EAF-S in a road layer are evaluated

⇒ We should take into account the use phase as EP and TP exhibit important impacts

⇒ Even if recycling this AM is possible regarding local regulation, water may leach chemical during the use phase by infiltration

⇒ Calculation using the Ecoinvent database appears to overestimate EP, TP

⇒ This result will be completed by other studies on different AM, as part of OFRIR database (http://ofrir.ifsttar.fr) where LCA is now its main objective

Thank you for your attention

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[avniR] Conference

7th edition, 8&9 November 2017, Lille

[avniR] Life Cycle Assessment Platform by cd2e

Session => TRANSPORT : Integrating Life Cycle Assessment and Sustainability Assessment into infrastructures design and management.

http://avnir.org/EN/Edition-2017-429.html

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