

EVALUATION ENVIRONNEMENTALE DE LA MOBILITÉ ÉLECTRIQUE : LEVIERS TECHNOLOGIQUES ET POLITIQUES D'AMÉLIORATION

**Séance d'information « Betriber & Umwelt »
22/10/2015**

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INSTITUTE
OF SCIENCE
AND TECHNOLOGY



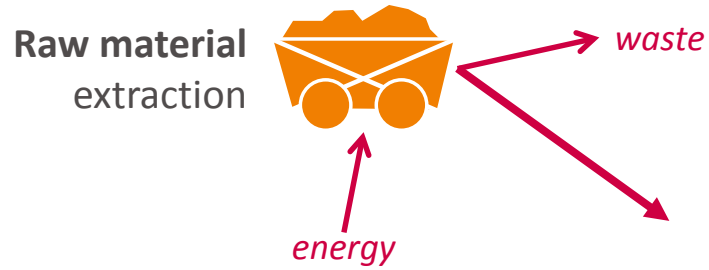
HYPOTHESIS

Does electro-mobility lead to superior environmental performances (i.e. to an overall reduction of the environmental impacts, in particular regarding Greenhouse Effect) as compared to the current situation?

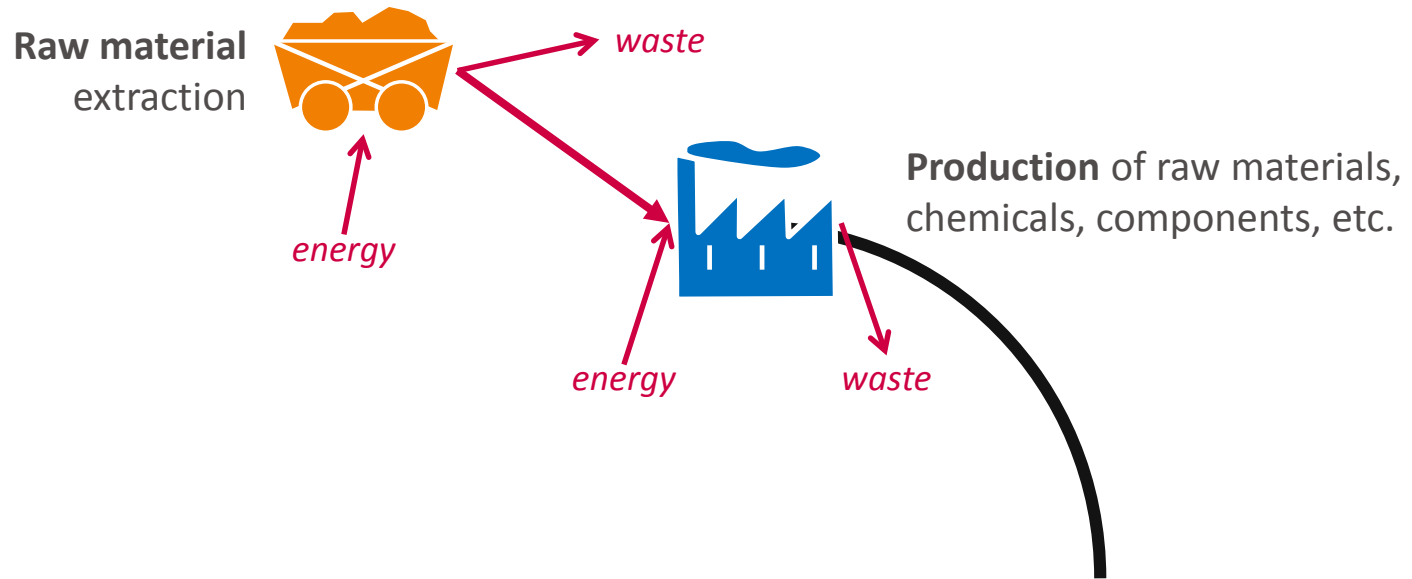
RESEARCH QUESTIONS

- 1. Are electric vehicles more environmentally friendly than conventional vehicles they are supposed to replace?*
- 2. What are the environmental consequences of policies promoting electro-mobility?*

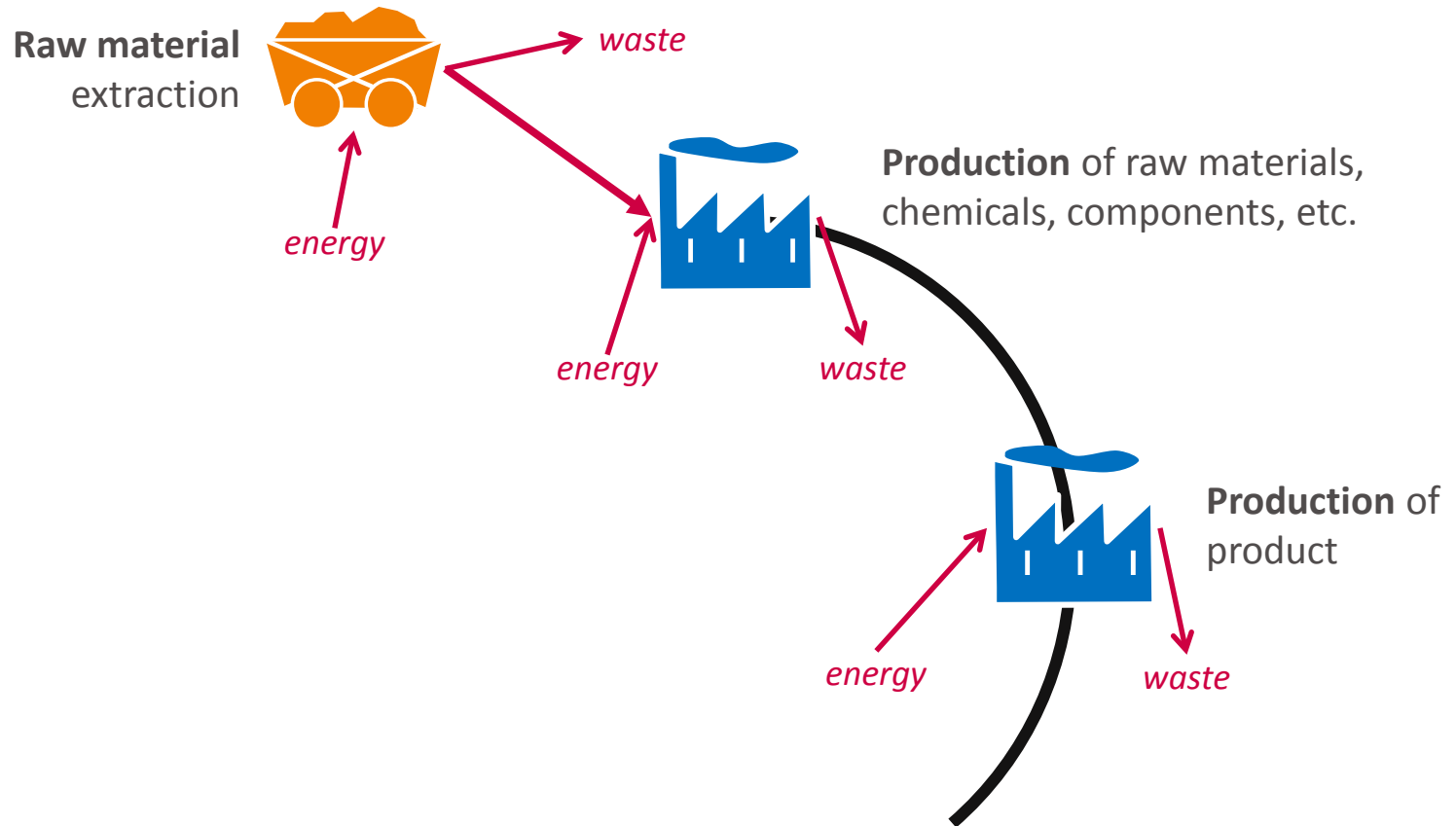
LIFE CYCLE ASSESSMENT (LCA) ISO 14040



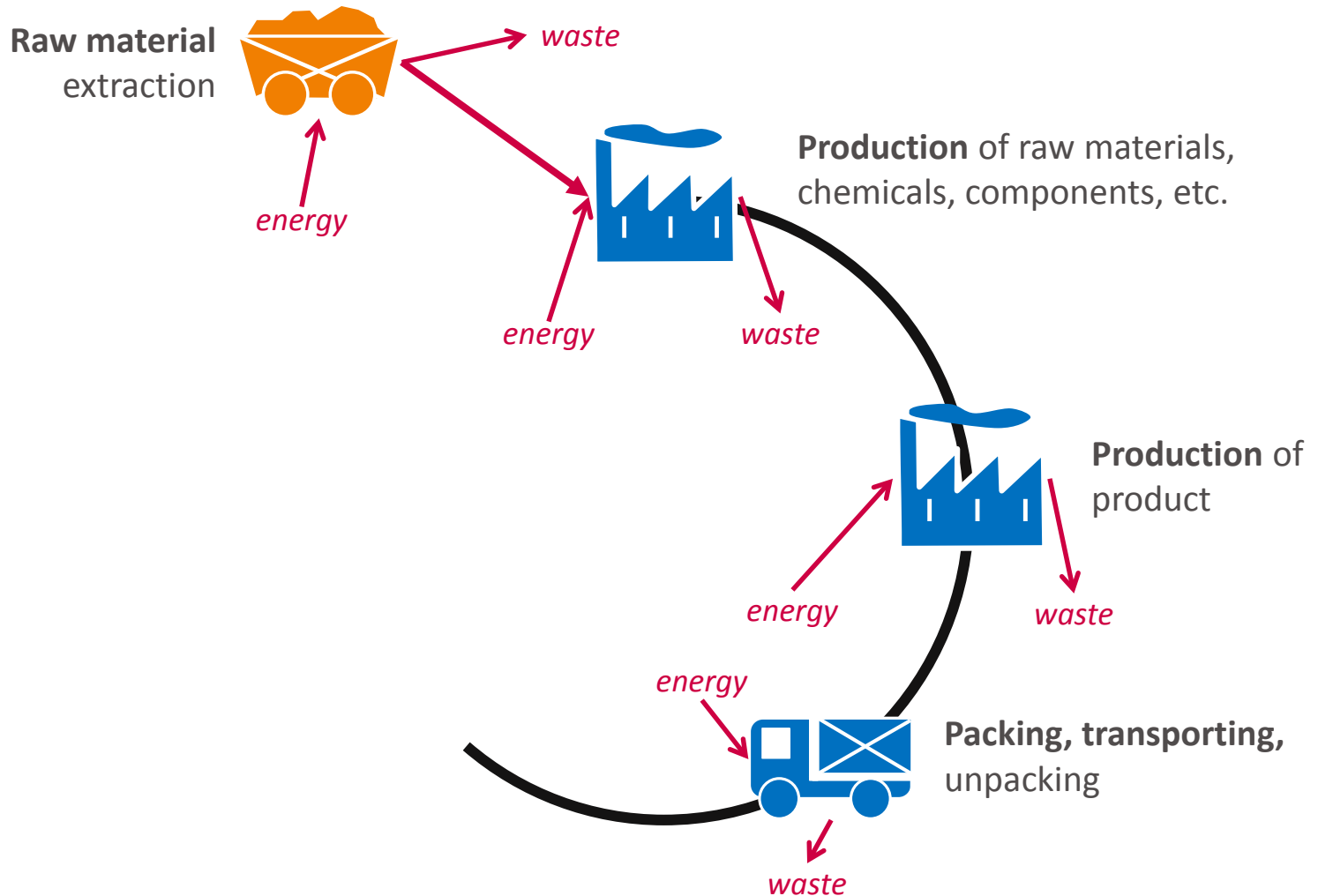
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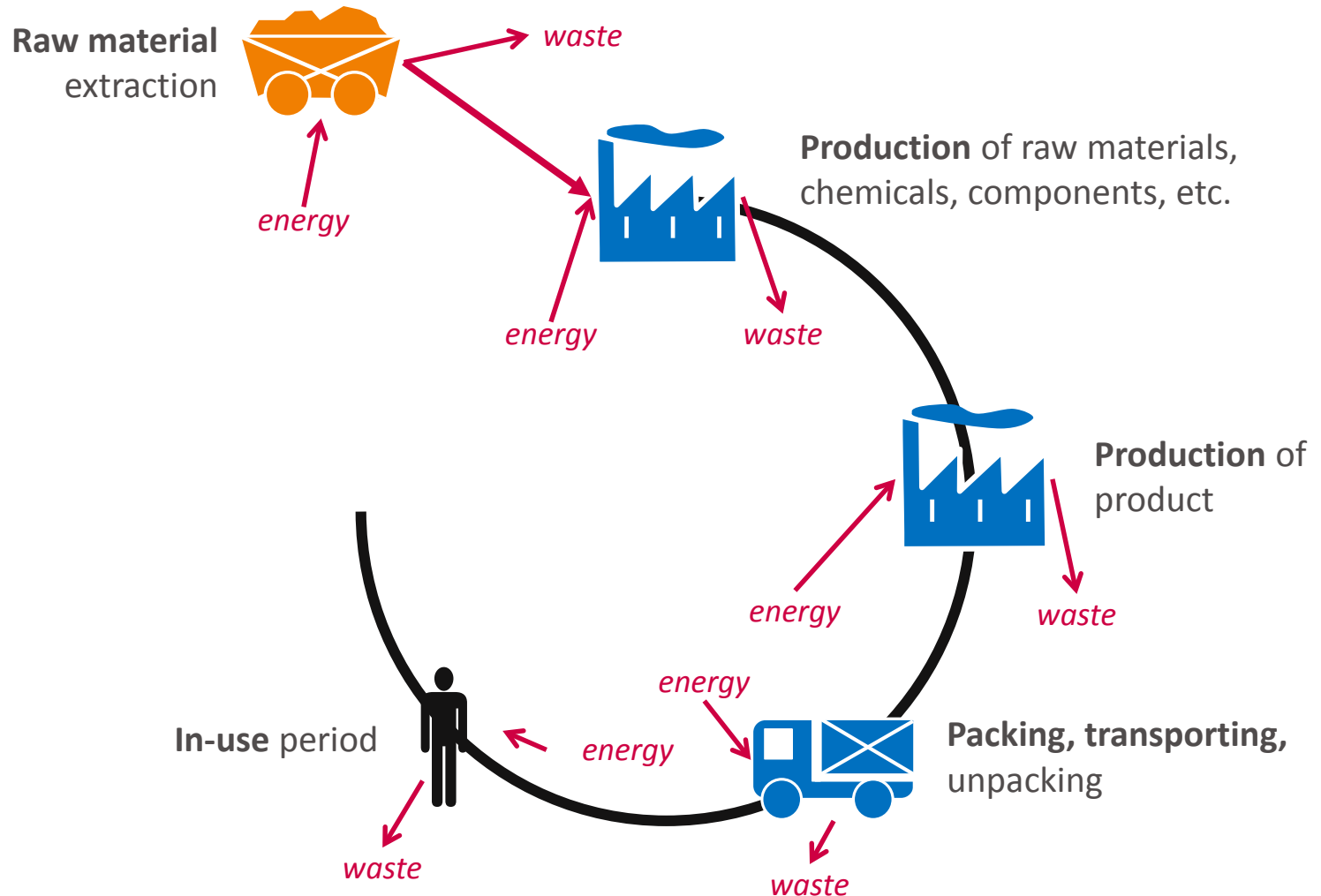
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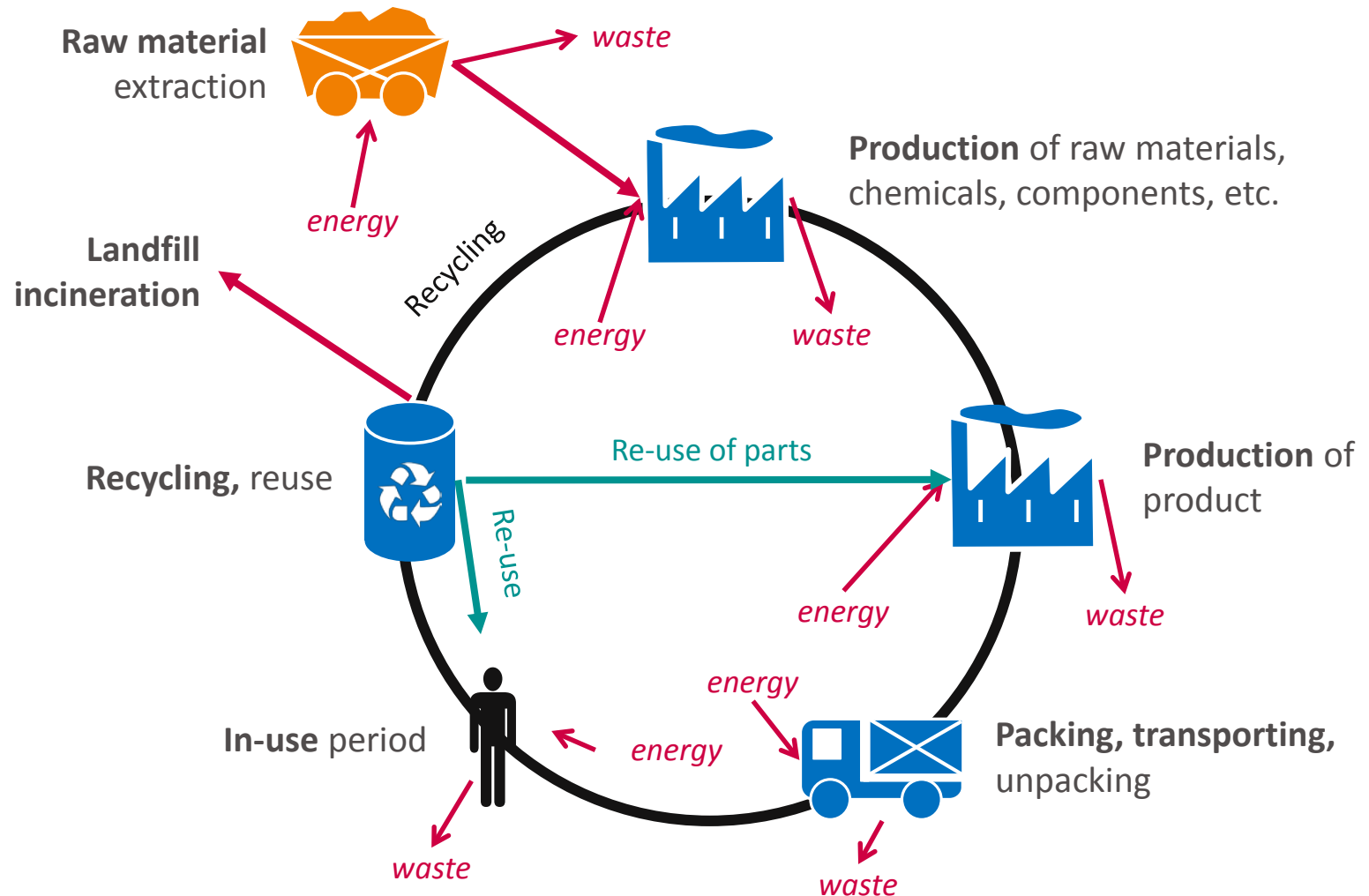
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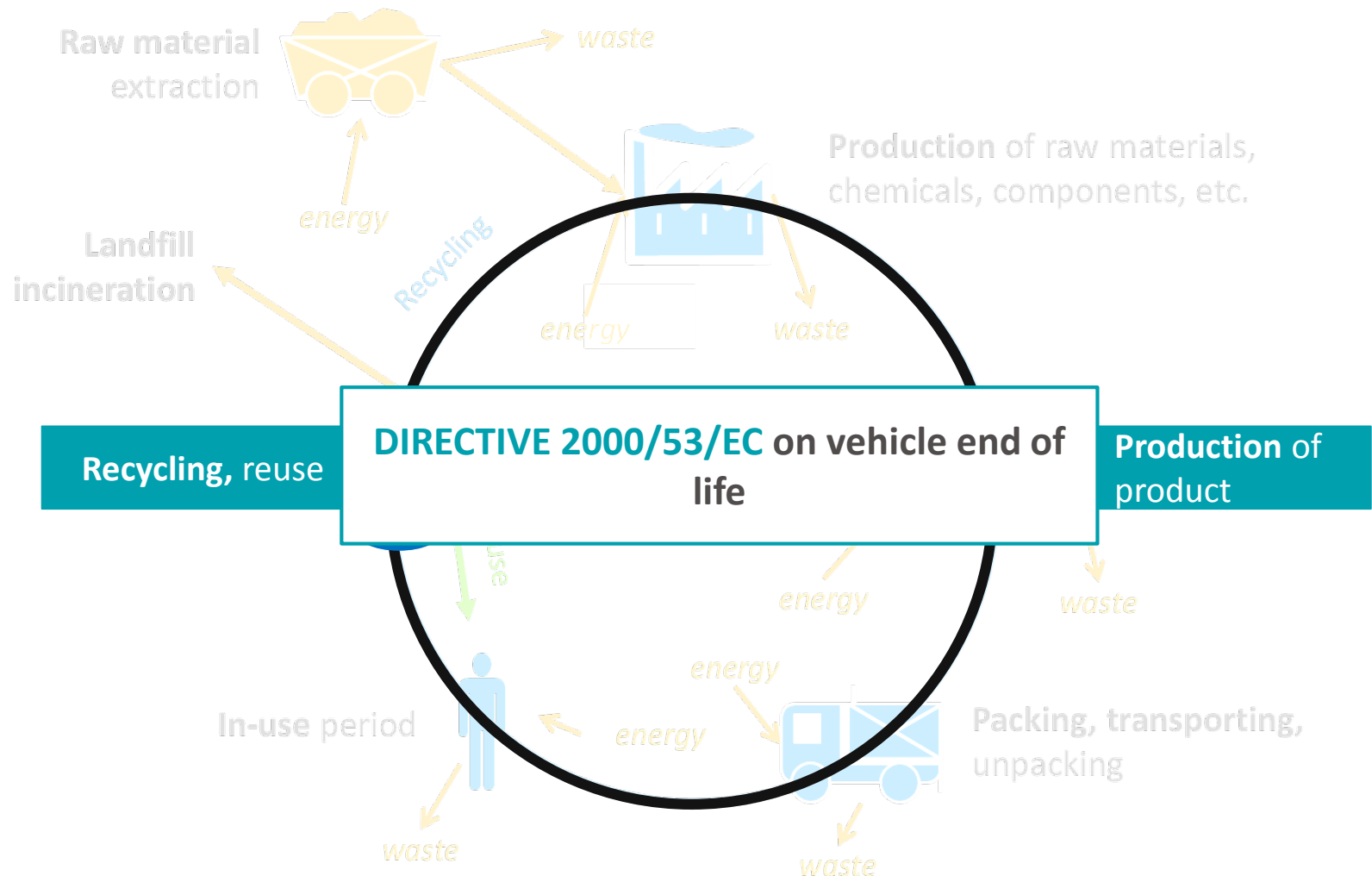
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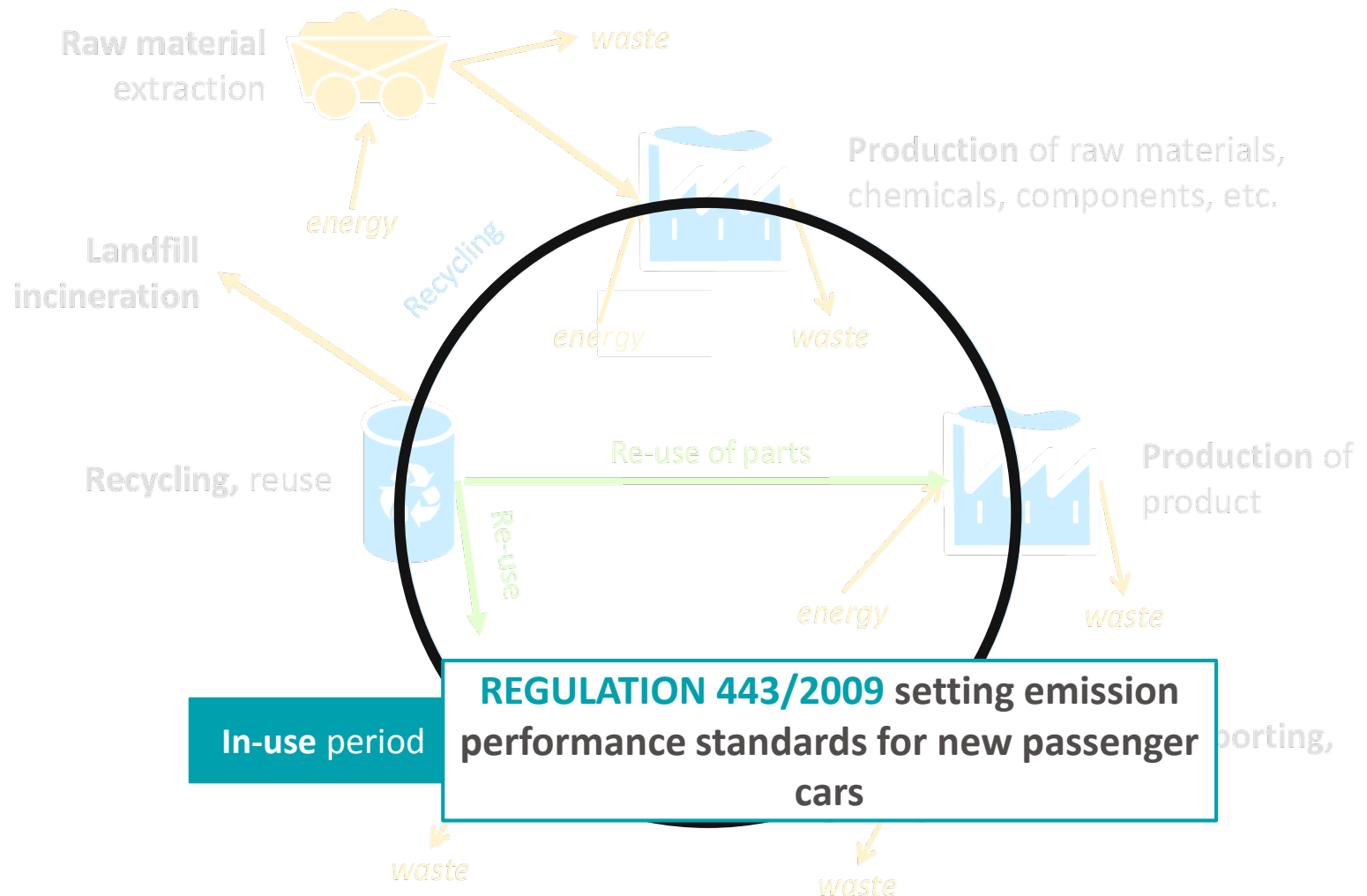
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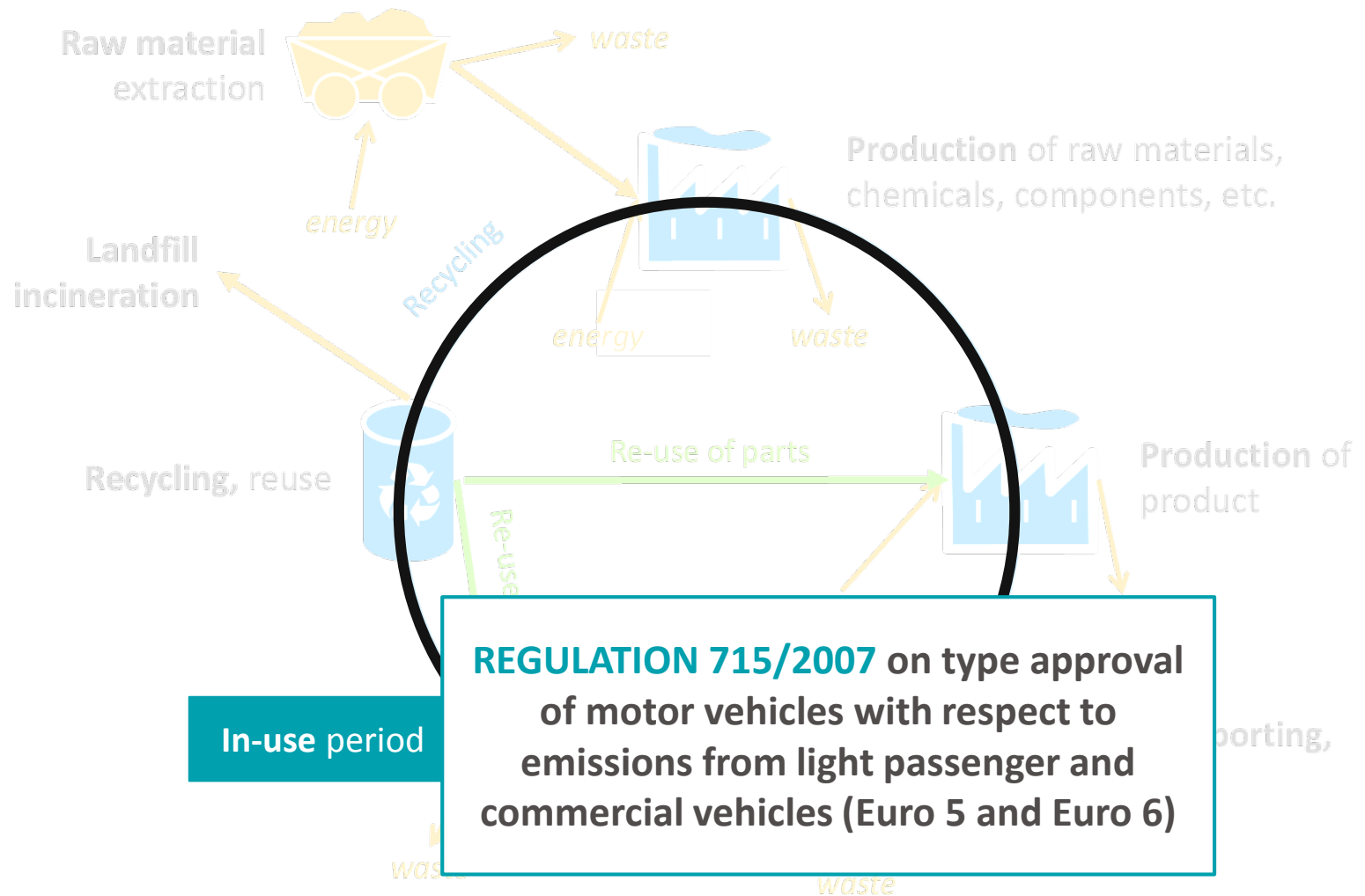
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LIFE CYCLE ASSESSMENT (LCA) ISO 14040



LCA IN PRACTICE

Life cycle inventory

10,000 to 100,000 LCI results

Environmental burdens (pollutant emissions, land transformation and occupation, noise, odours, ..), [kg], [m2a]

Consumption of resources (fossil fuels, minerals); [kg], [MJ]

Aggregation over the lifecycle

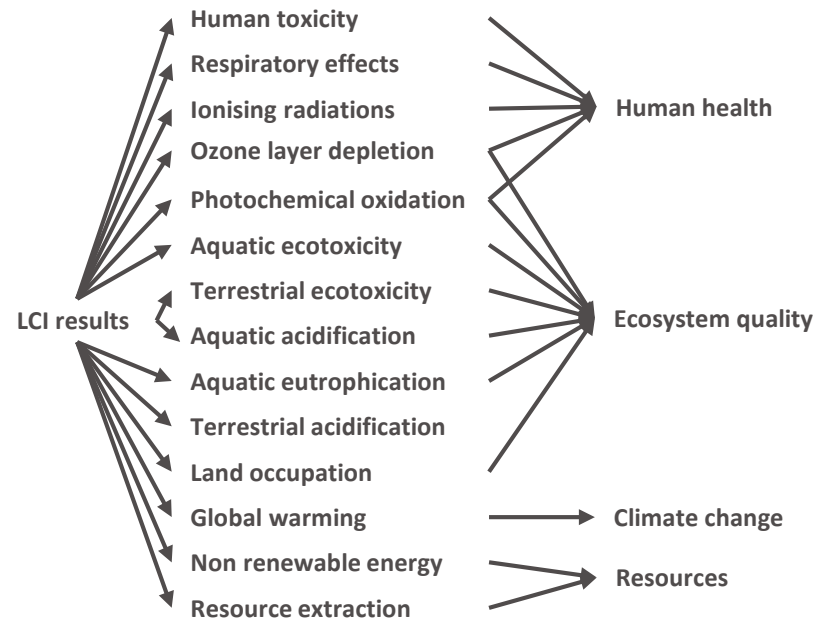
Up to 2,000 aggregated LCI results

Impact assessment (valuation) methods :
CML2002, Ecoindicator99, EDIP, Impact 2002+, ReCiPe, Impact World

Life cycle impact assessment; e.g. IMPACT 2002+

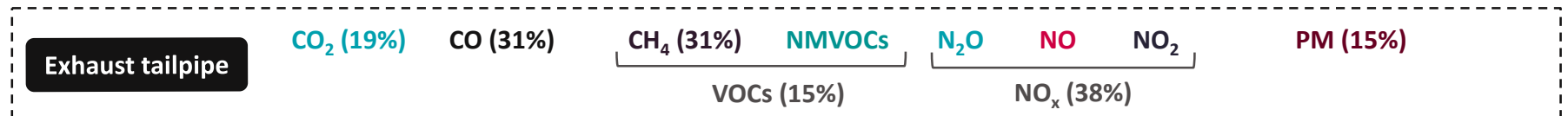
Midpoint impact assessment

Endpoint impact assessment (dommages)

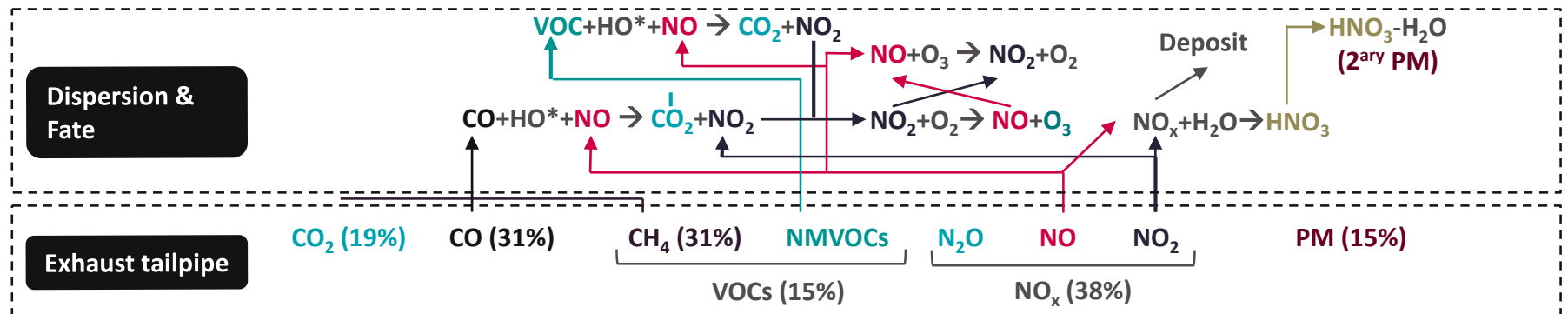


Adapted from Impact2002+ report

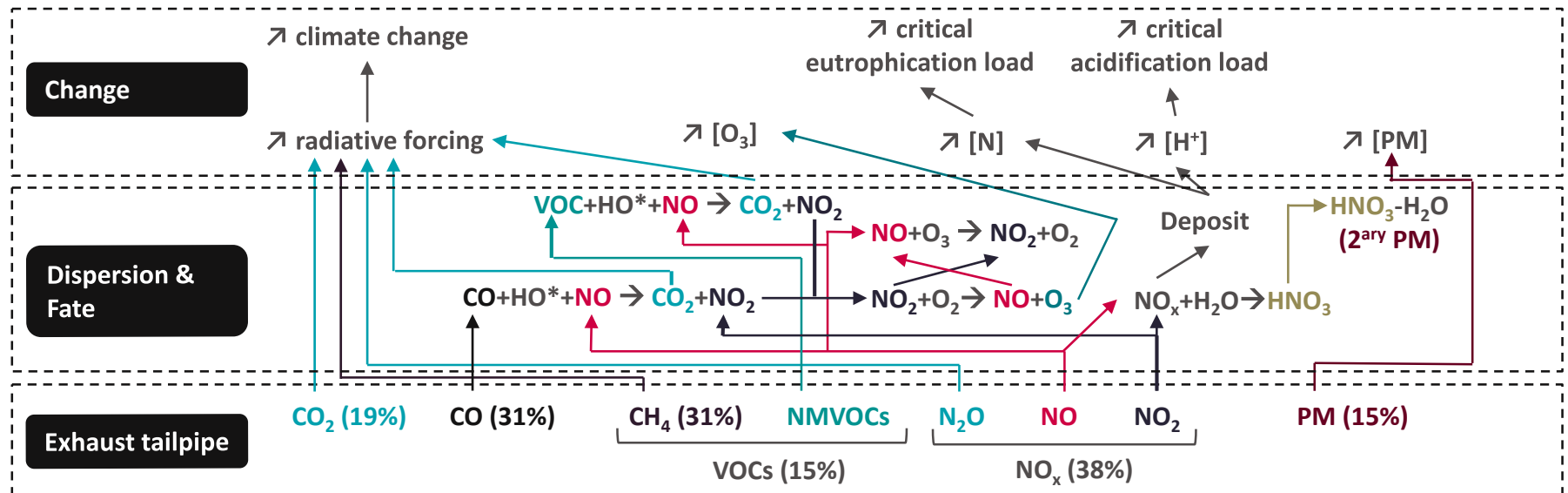
IMPACT ILLUSTRATION: TAILPIPE EXHAUST EXAMPLE



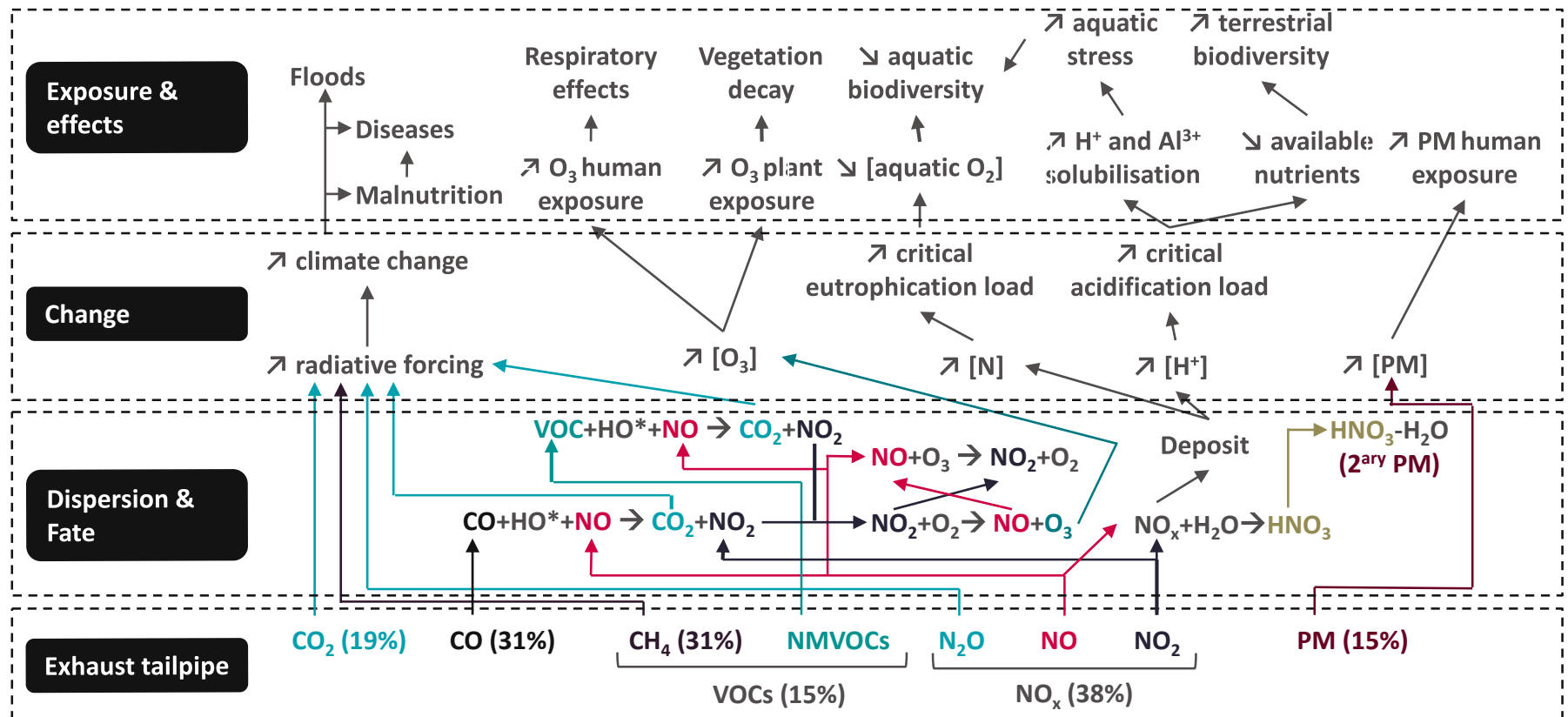
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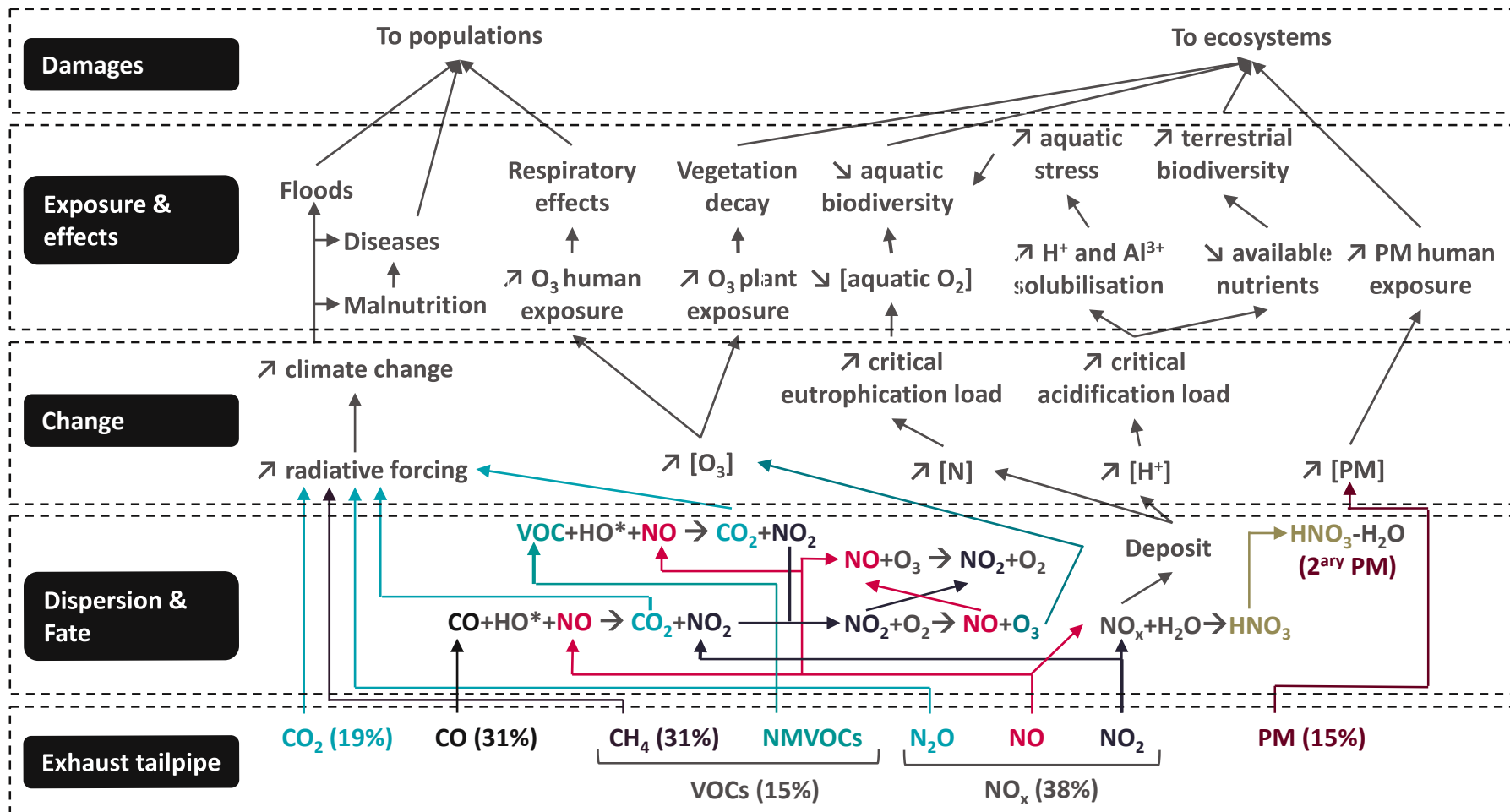
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IMPACT ILLUSTRATION: TAILPIPE EXHAUST EXAMPLE



CASE STUDY DESCRIPTION

- **New A-segment electric car (Peugeot Ion) for employees trips.**
- **Charging when the car is back at office.**
- **Car replaces equivalent ICEV (Peugeot 108, Citroën C1, Renault Twingo, Fiat 500, etc.)**

COMPARISON METHODOLOGY

Vehicles separated in 2 main parts:

1. GLIDER: identical for all vehicles

2. POWERTRAIN: different between vehicles

GLIDER COMPOSITION

BODY AND DOORS

Vehicle body hardware	1.4%
Vehicle body (base)	48.6%
Vehicle body panel	15.5%
Weld blanks and fasteners	3.3%
Rear screen glass	0.9%
Side screen glass	2.5%
Vehicle doors and lids	23.7%
Windscreen glass	2.3%
Steel bumper	1.9%

CHASSIS

Steel cradle	16.0%
Steel driveshaft	39.6%
Steel corner suspension	21.8%
Steering system	11.9%
Chassis electrical components	5.3%
Steel weld blanks & fasteners	5.3%

WHEELS AND BRAKES

Disc brake	9.1%
Tyres	32.0%
Steel wheel rim	58.8%

SEATS

Squab	5.8%
Cushion	9.1%
Seat belt	0.6%
Height control	0.4%
Head rest	0.8%
Seats, other	83.2%

DASHBOARD, PANELS, TRIM AND INSULATION

Centre console	1.0%
Dashboard	13.3%
Glove box	3.8%
Air duct	0.4%
Steering finisher	0.2%
Other instrumentation	21.1%
A-post finisher	1.5%
B-post finisher	0.8%
C-post finisher	1.5%
Sill finsher	1.5%
Other trim	33.5%
Doors	21.5%

INTERIORS, LOAD SPACE AND OTHERS

Electrical	7.4%
Welders	7.4%
Load space wheel arc finishers	1.1%
Load space finishers	0.3%
Load space latch finishers	2.6%
Tool box	2.8%
HVAC	78.4%

EXTERIORS

Paint	28.9%
Underbody	2.1%
Bumper covers	1.2%
Wheel arc closures	9.4%
Road wheel finishers	0.4%
Bumpers	24.8%
Rear lamps	4.4%
Radiator	0.7%
Other	1.4%
Sealers	2.2%
Electrical	24.4%

ICEV-SPECIFIC COMPOSITION

ICE POWERTRAIN: ENGINE

ICE Block and other	57.8%
ICE Camshaft	1.6%
ICE Connecting rod	1.4%
ICE Crankcase	21.5%
ICE Crankshaft	6.0%
ICE Cylinder head	6.2%
ICE Flywheel	4.7%
ICE Hydraulic valve filter	0.2%
ICE Intake valve	0.2%
ICE Ring gear	0.5%

ICE POWERTRAIN: GEAR BOX

Gear box casing	31.6%
Gear box differential	18.5%
Gear box input shaft	15.4%
Gear box output shaft	16.3%
Gear box shift parts	2.9%
Gear box, others	15.3%

FLUIDS

Power steering fluid	1.6%
Damper oil	0.7%
Brake fluid	4.4%
Windshield wiper fluid	9.3%
Refrigerant fluid	1.5%
Engine oil (ICE only)	7.0%
Powertrain coolant (ICE only)	14.1%
Gasoline (ICE only)	61.3%

BATTERIES

Pb battery	100.0%
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ICE POWERTRAIN: OTHERS

Air cleaning housing	1.0%
Coolant expansion tank	0.3%
Emission control electronics	8.6%
Exhaust pipe	38.7%
Exhaust pipe catalysts	3.2%
Fuel tank	10.1%
Pollen filter housing	0.3%
Weld blanks and fasteners, Powertrain thermal to body	8.6%
ICE powertrain, electrical	8.6%
ICE powertrain, thermal	20.7%

EV-SPECIFIC COMPOSITION

ELECTRIC COMPONENTS

Inverter	29.4%
Battery cooling system	31.9%
Charger	29.4%
Controller	9.4%

ELECTRIC MOTOR

Engine, copper windings	27.8%
Engine, neodymium magnet	4.3%
Engine, others	68.0%

BATTERIES

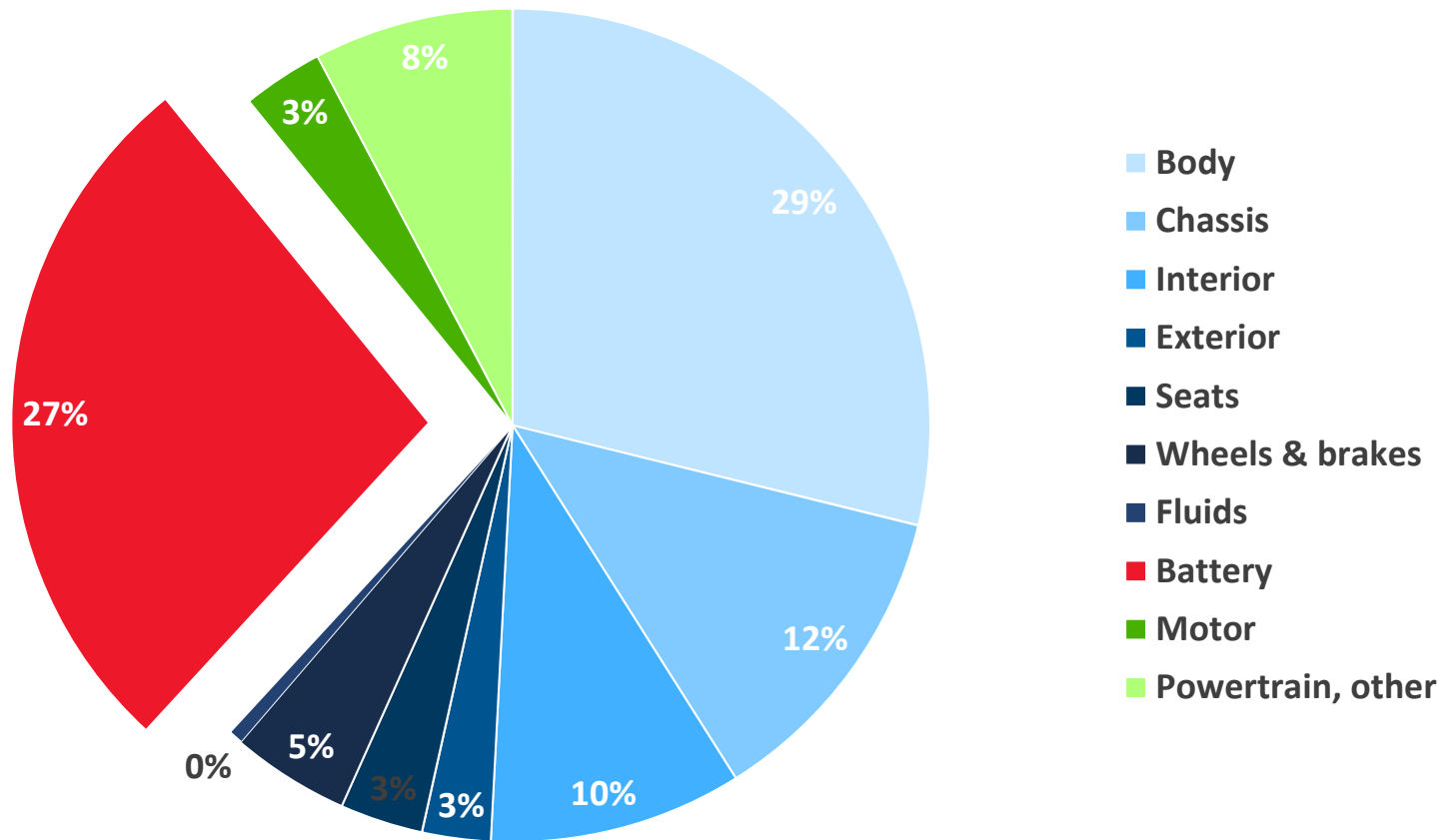
LiMn2O4 battery	100.0%
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FLUIDS

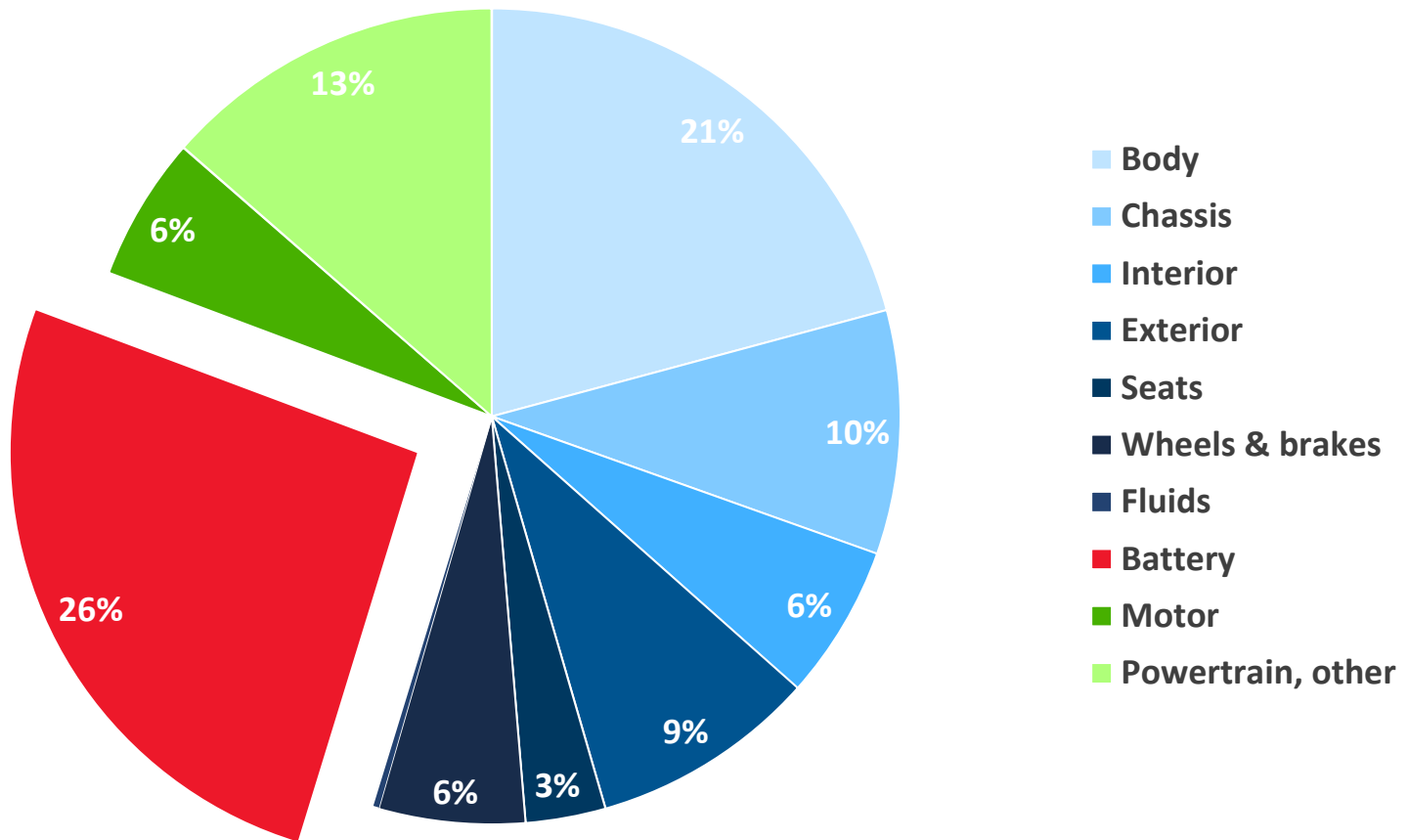
Power steering fluid	1.6%
Damper oil	0.7%
Brake fluid	4.4%
Windshield wiper fluid	9.3%
Refrigerant fluid	1.5%

Adapted from Hawkins et al. 2012, Majeau-Bettez et al. 2013, Notter et al. 2008

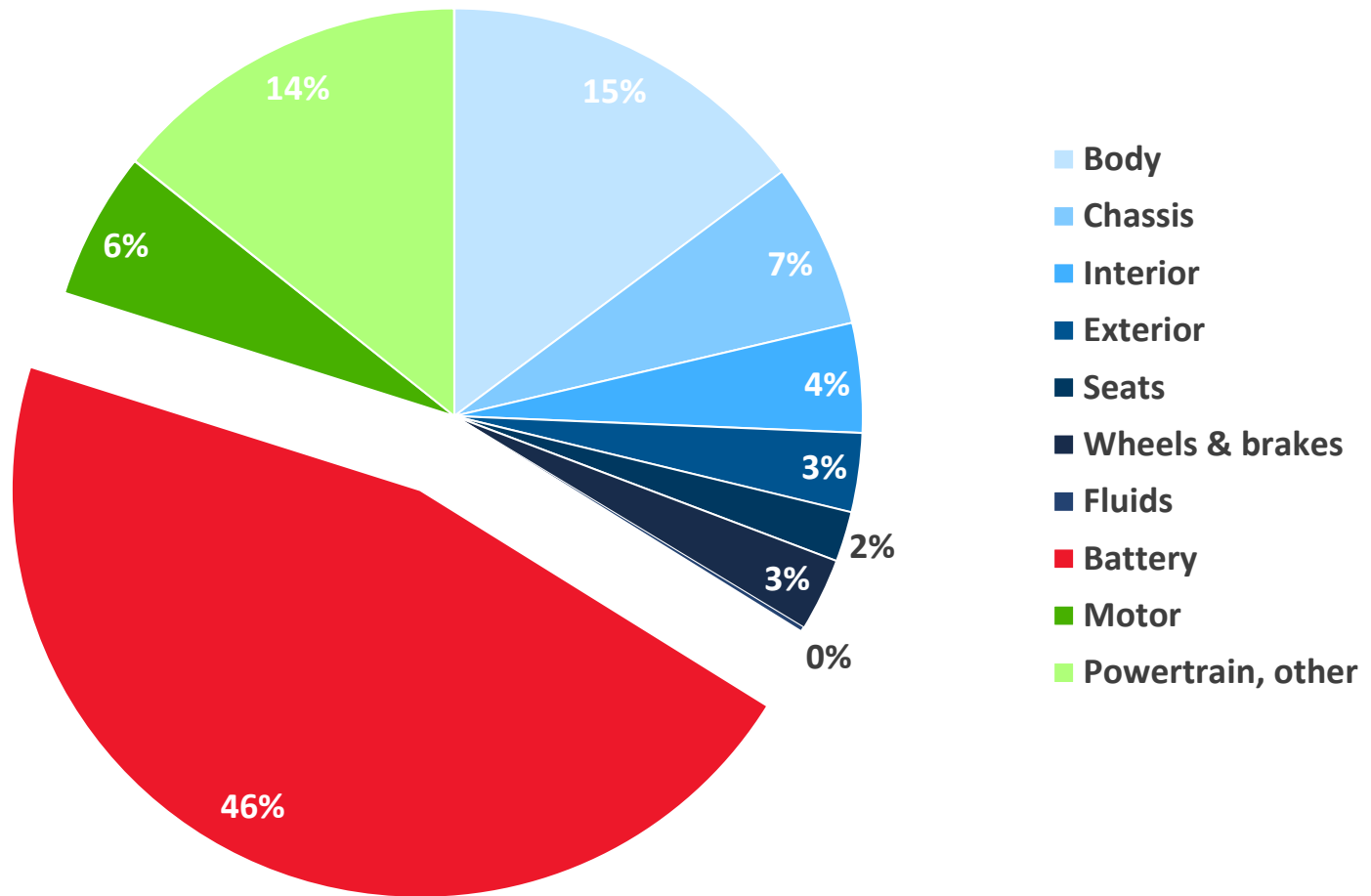
PRODUCTION OF BEV: MASS REPARTITION



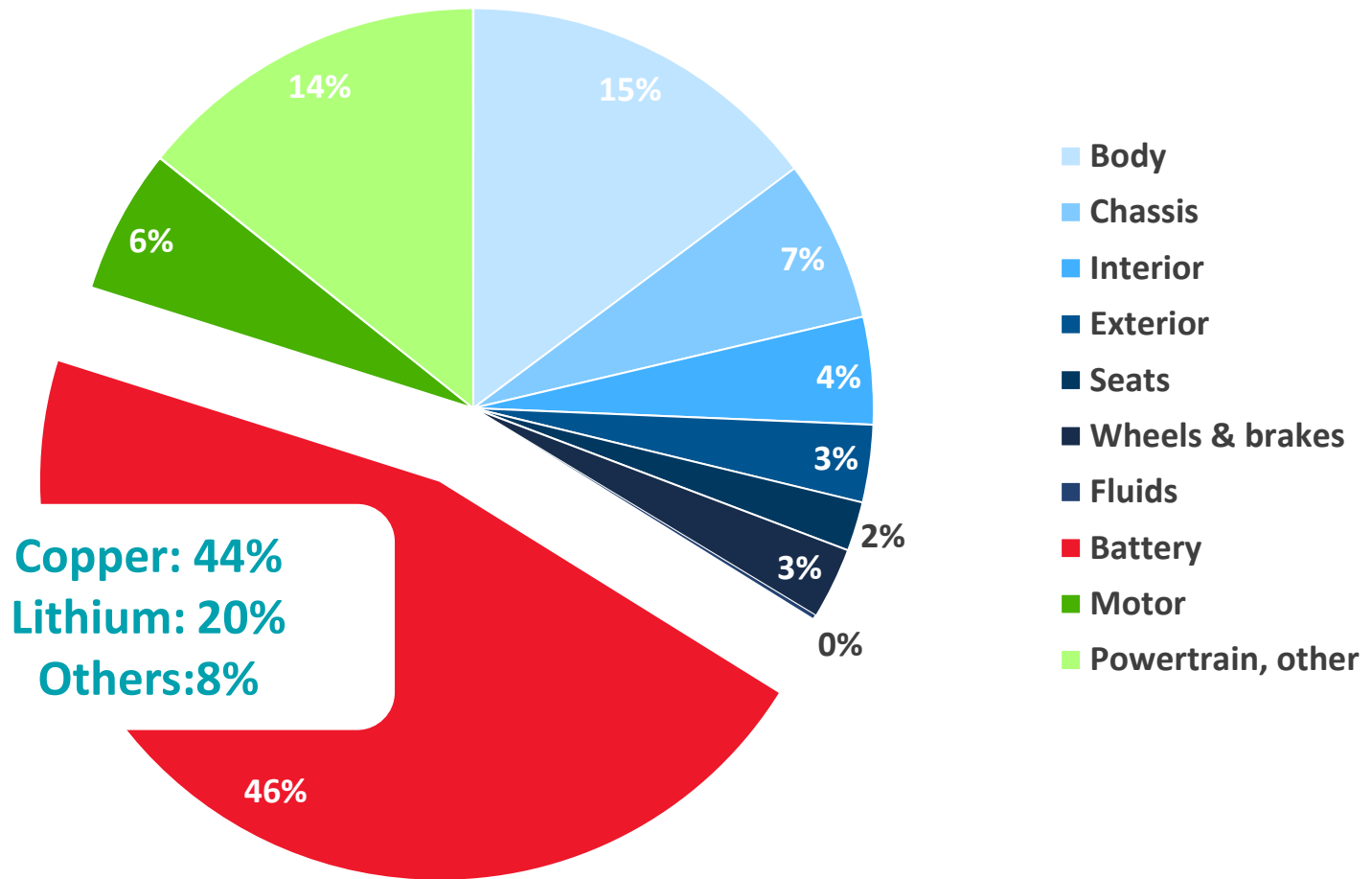
PRODUCTION OF BEV: GWP100



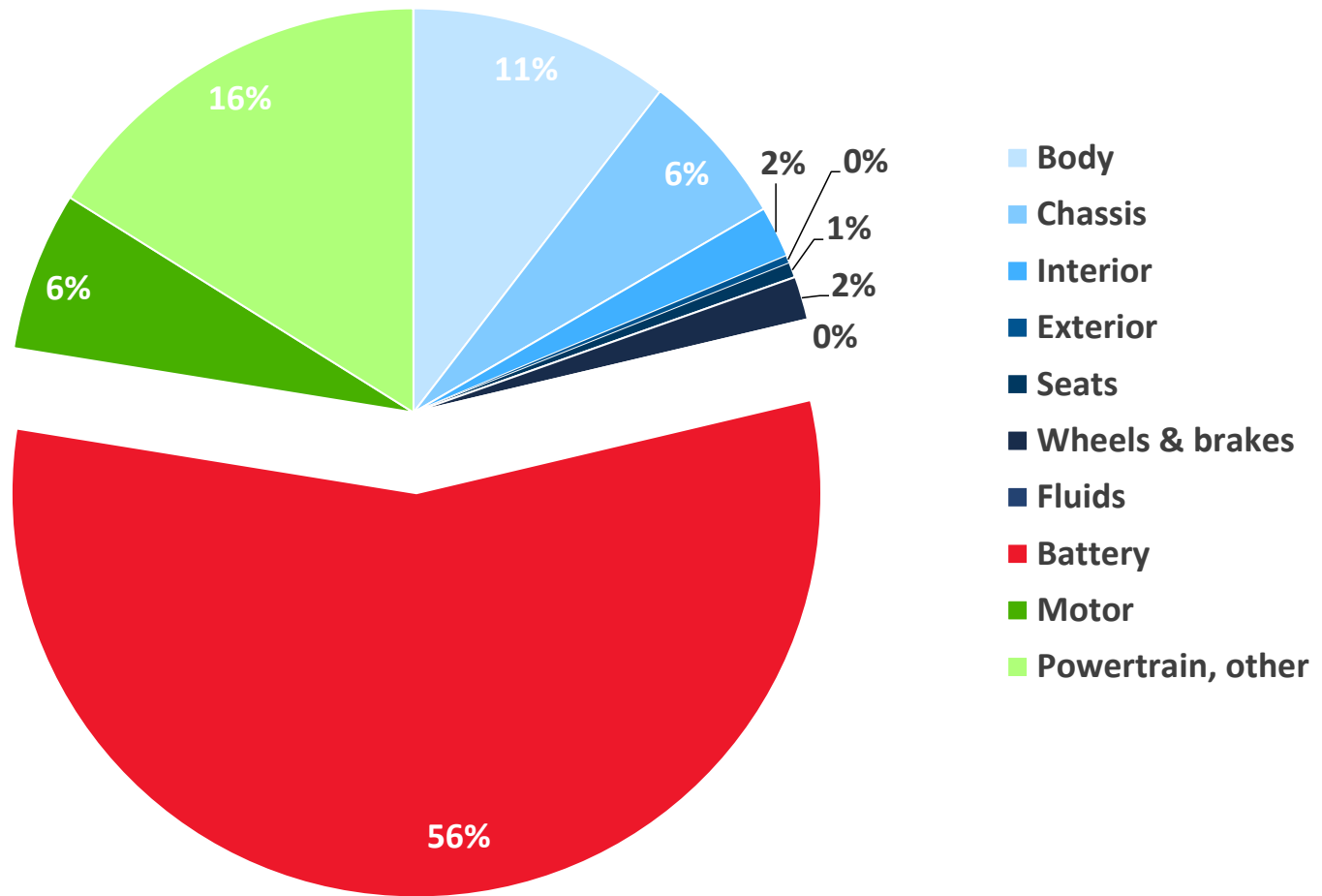
PRODUCTION OF BEV: TAP100



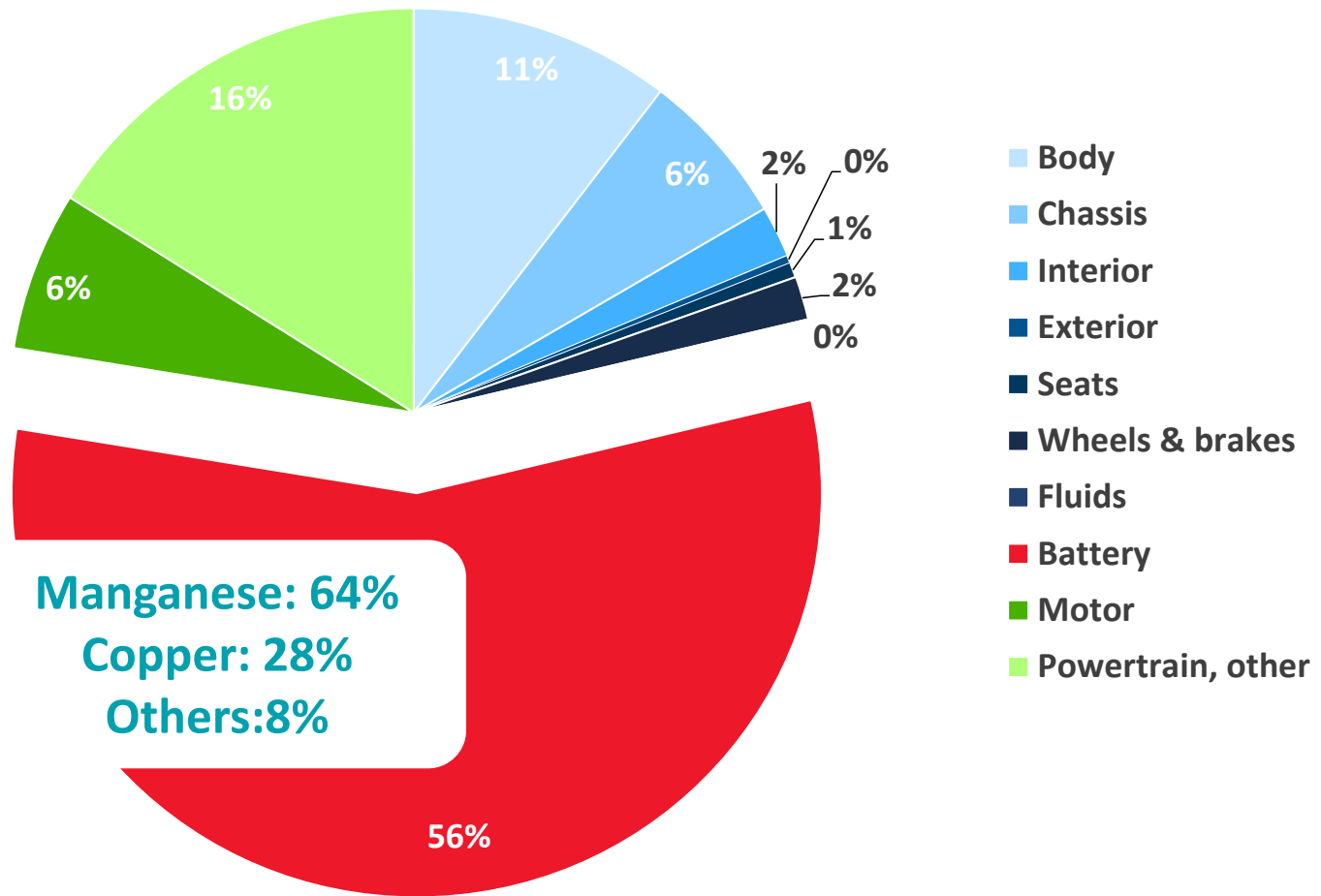
PRODUCTION OF BEV: TAP100



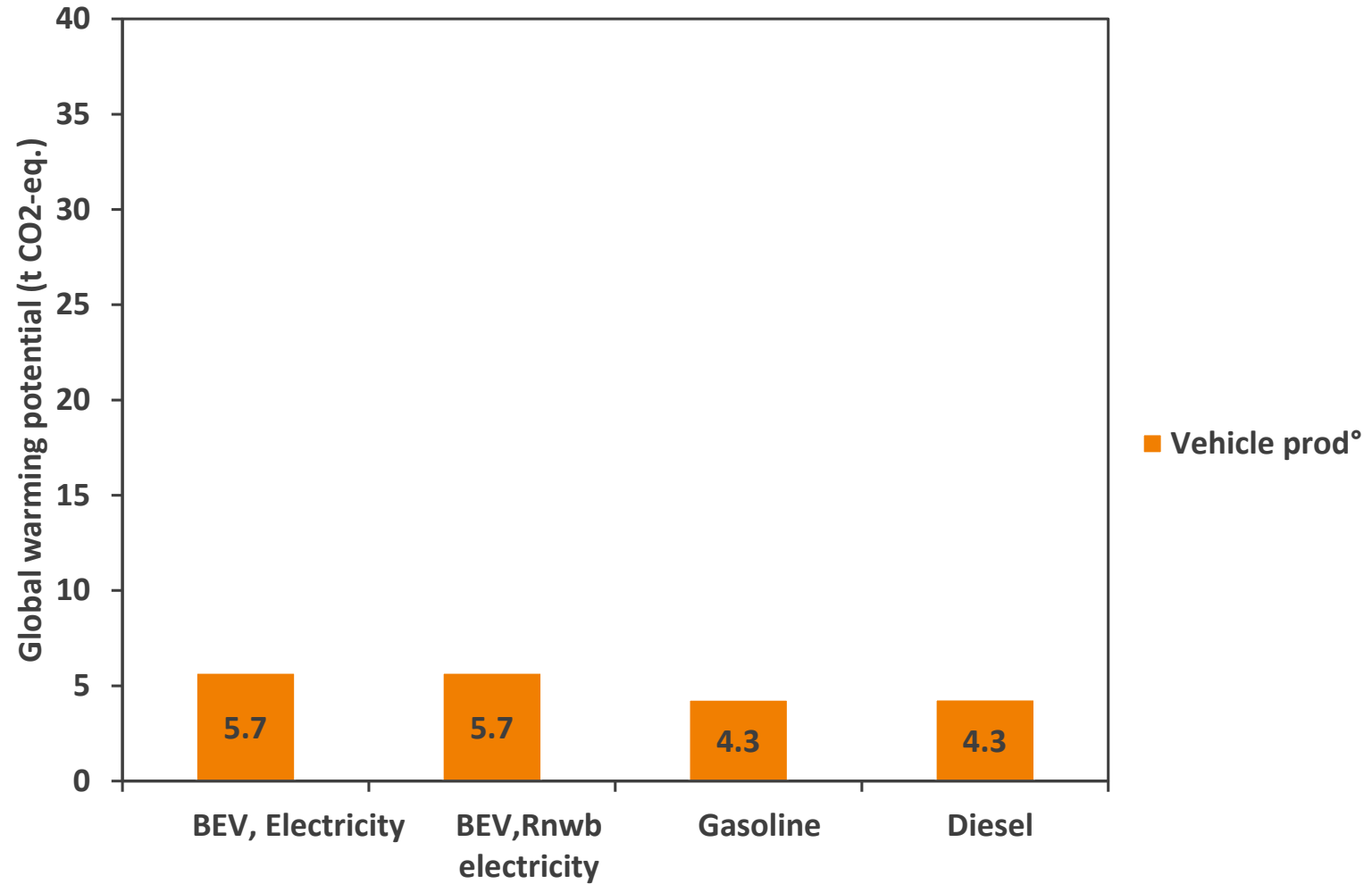
PRODUCTION OF BEV: MDP



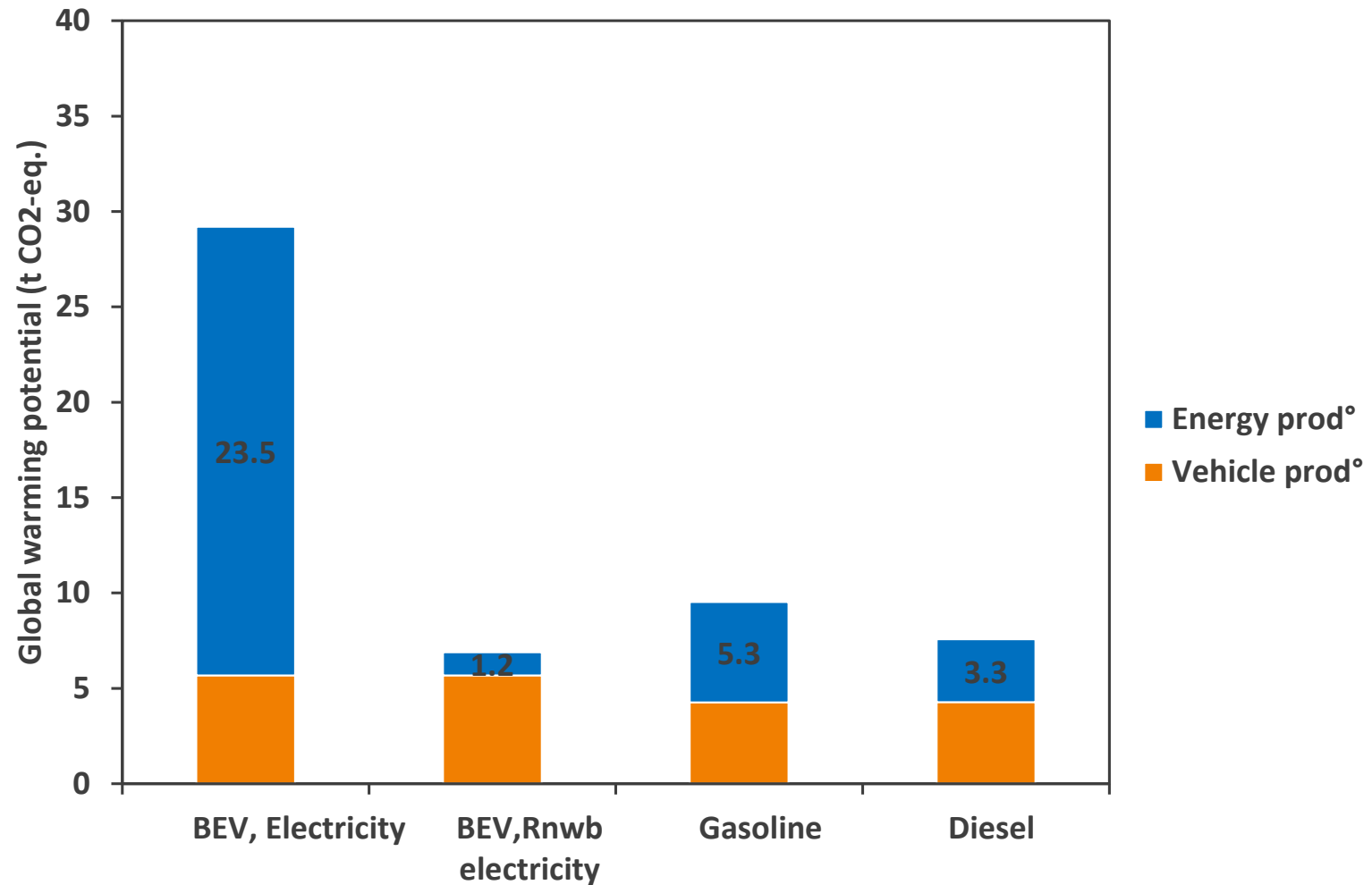
PRODUCTION OF BEV: MDP



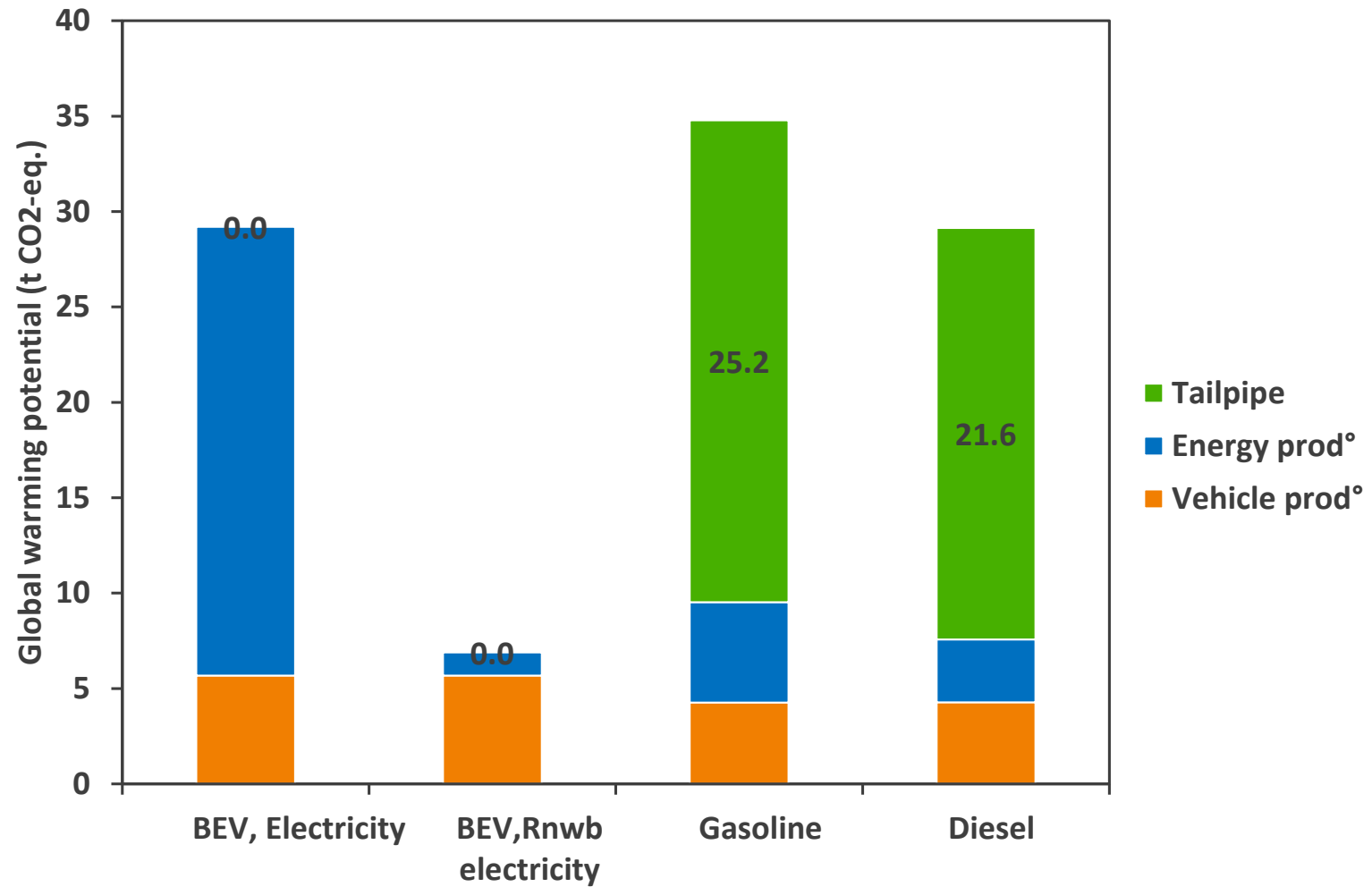
GWP, 150 000 KM, URBAN DRIVING



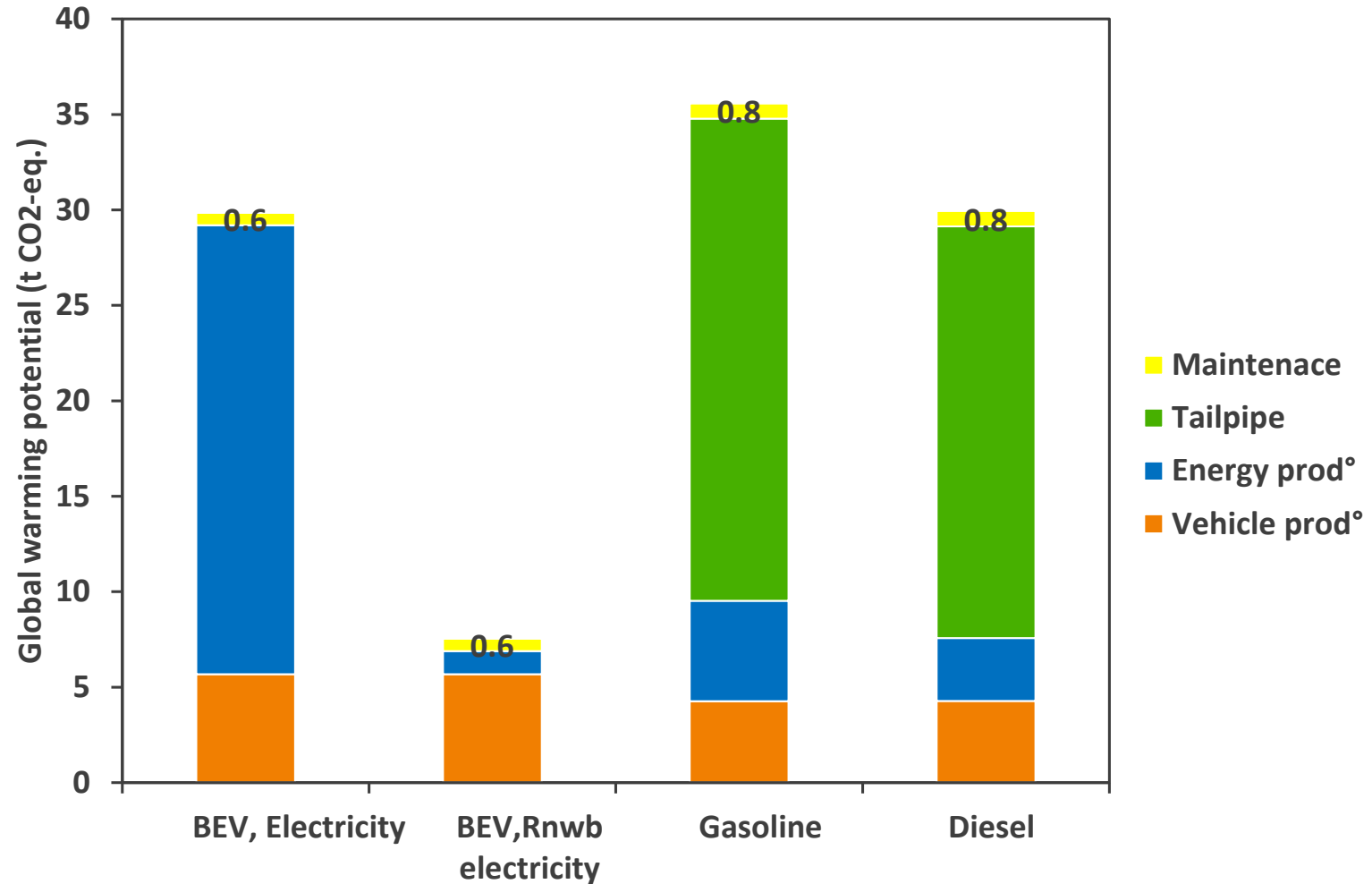
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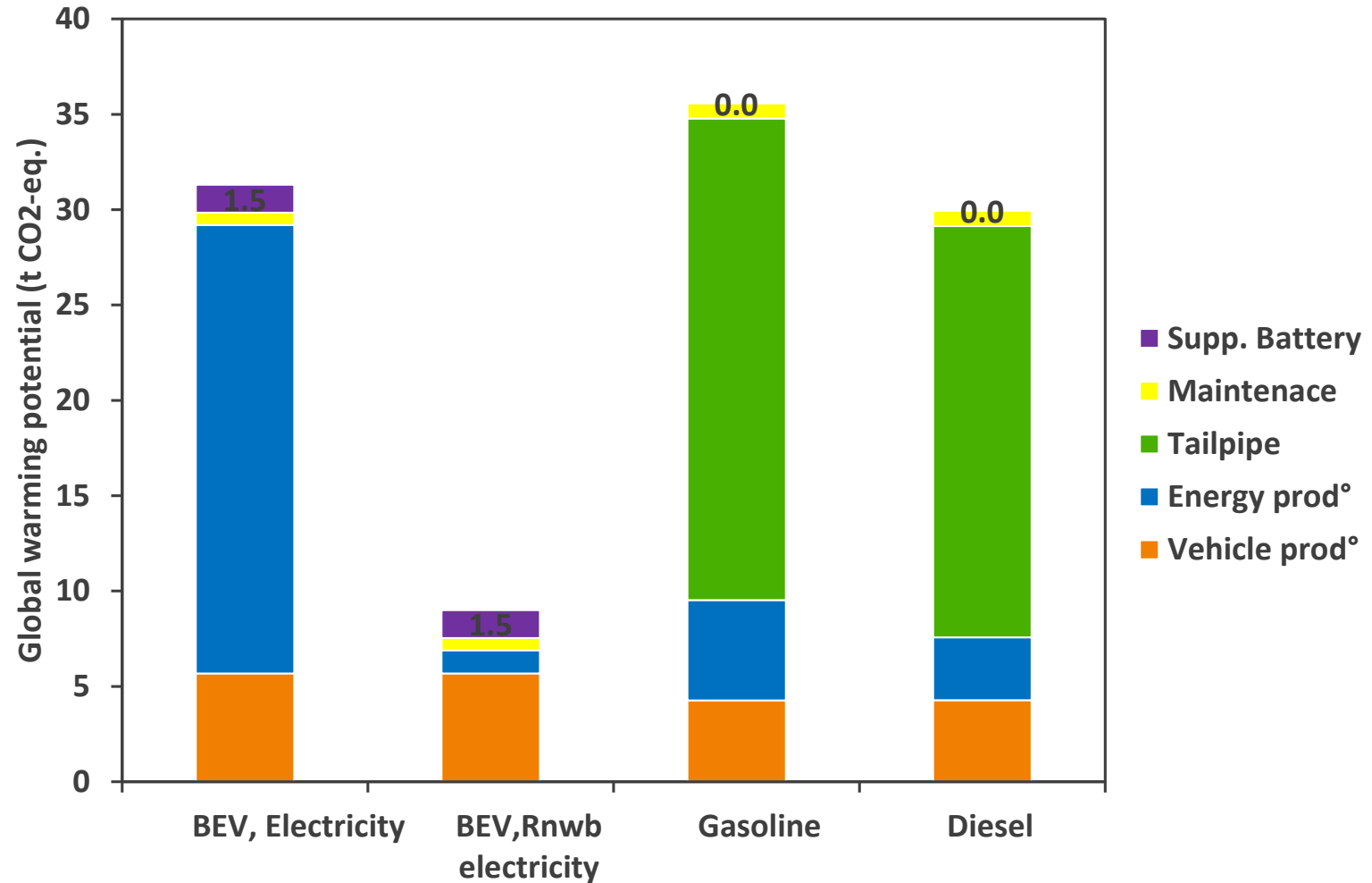
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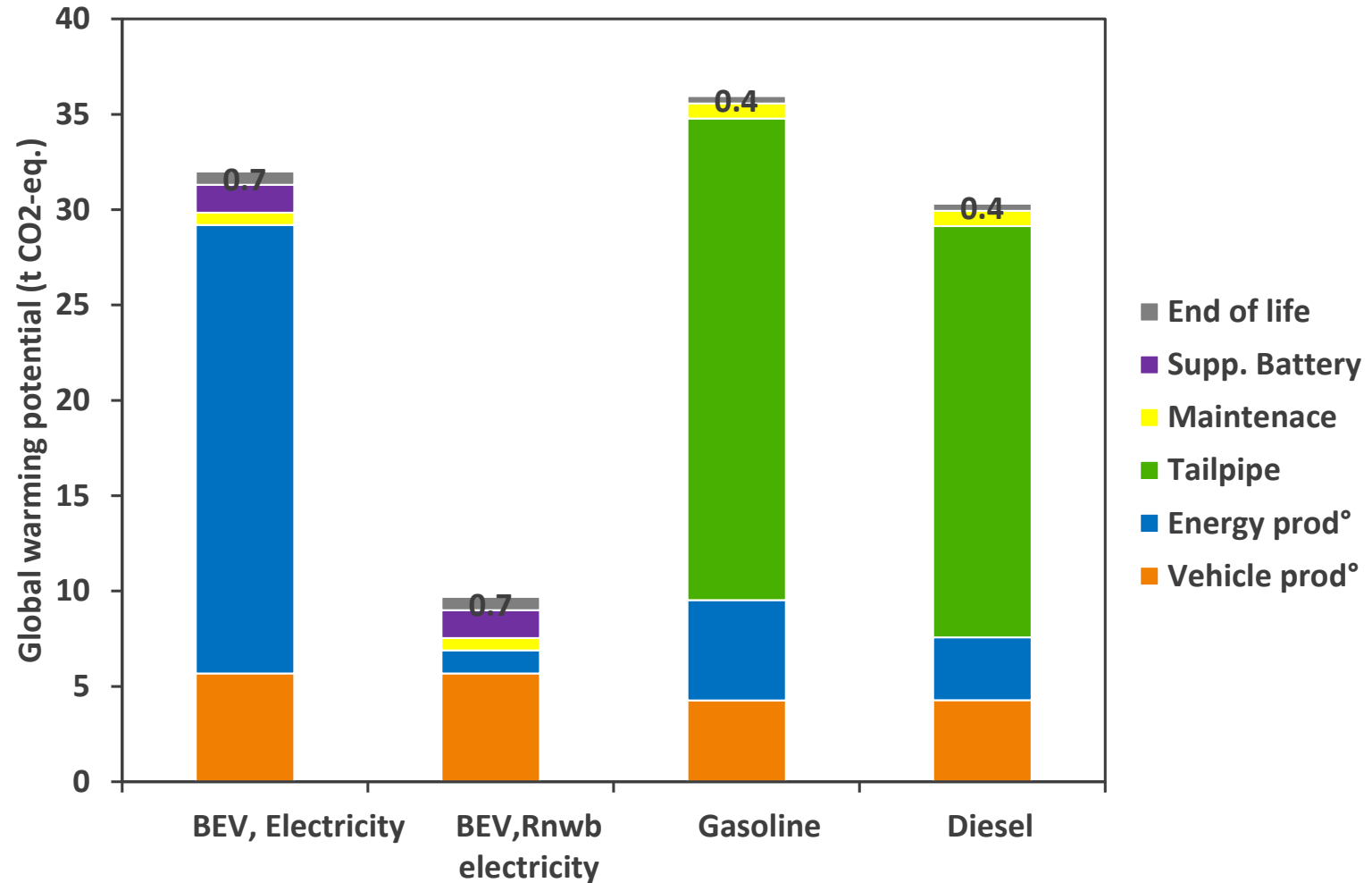
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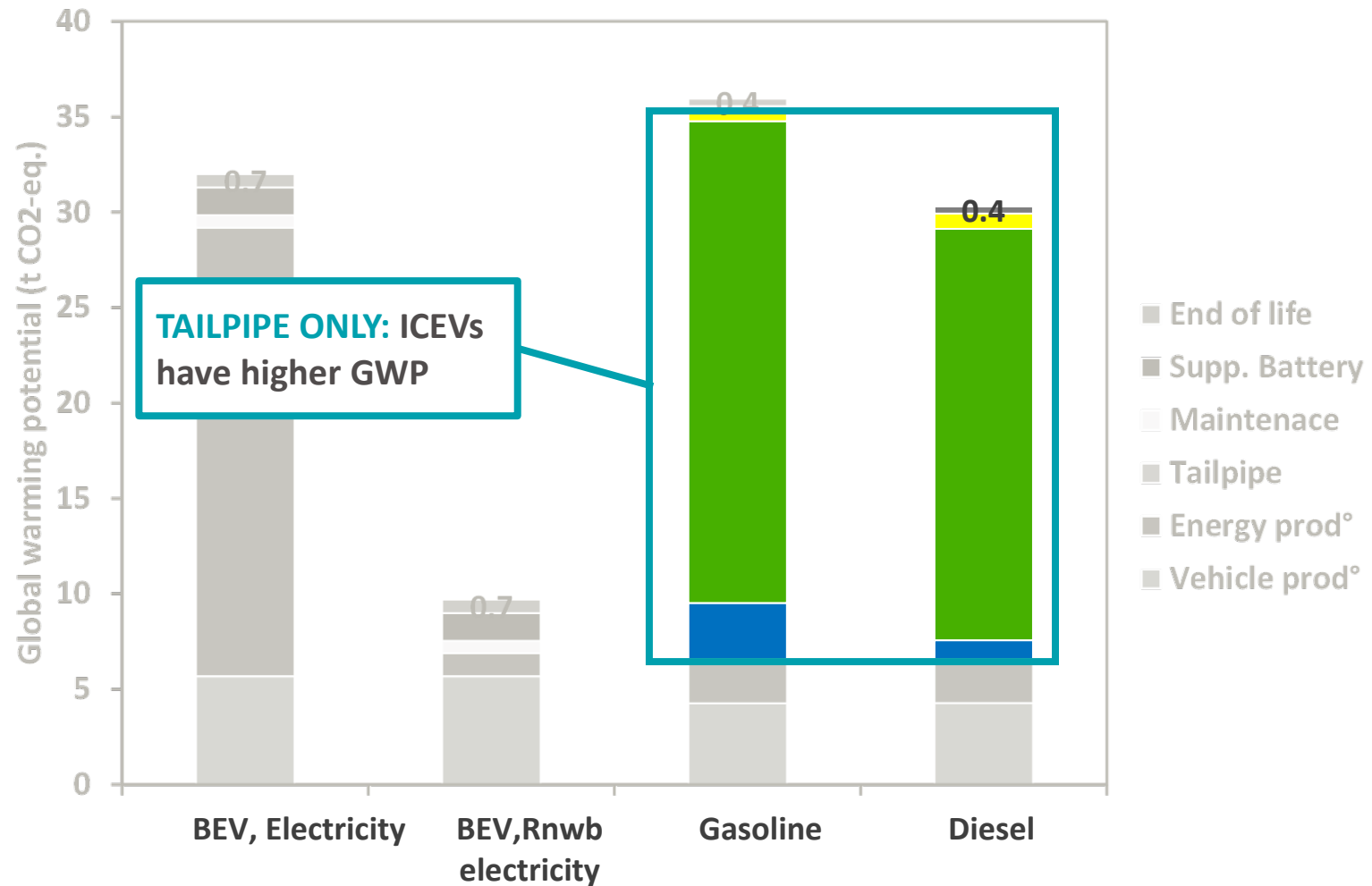
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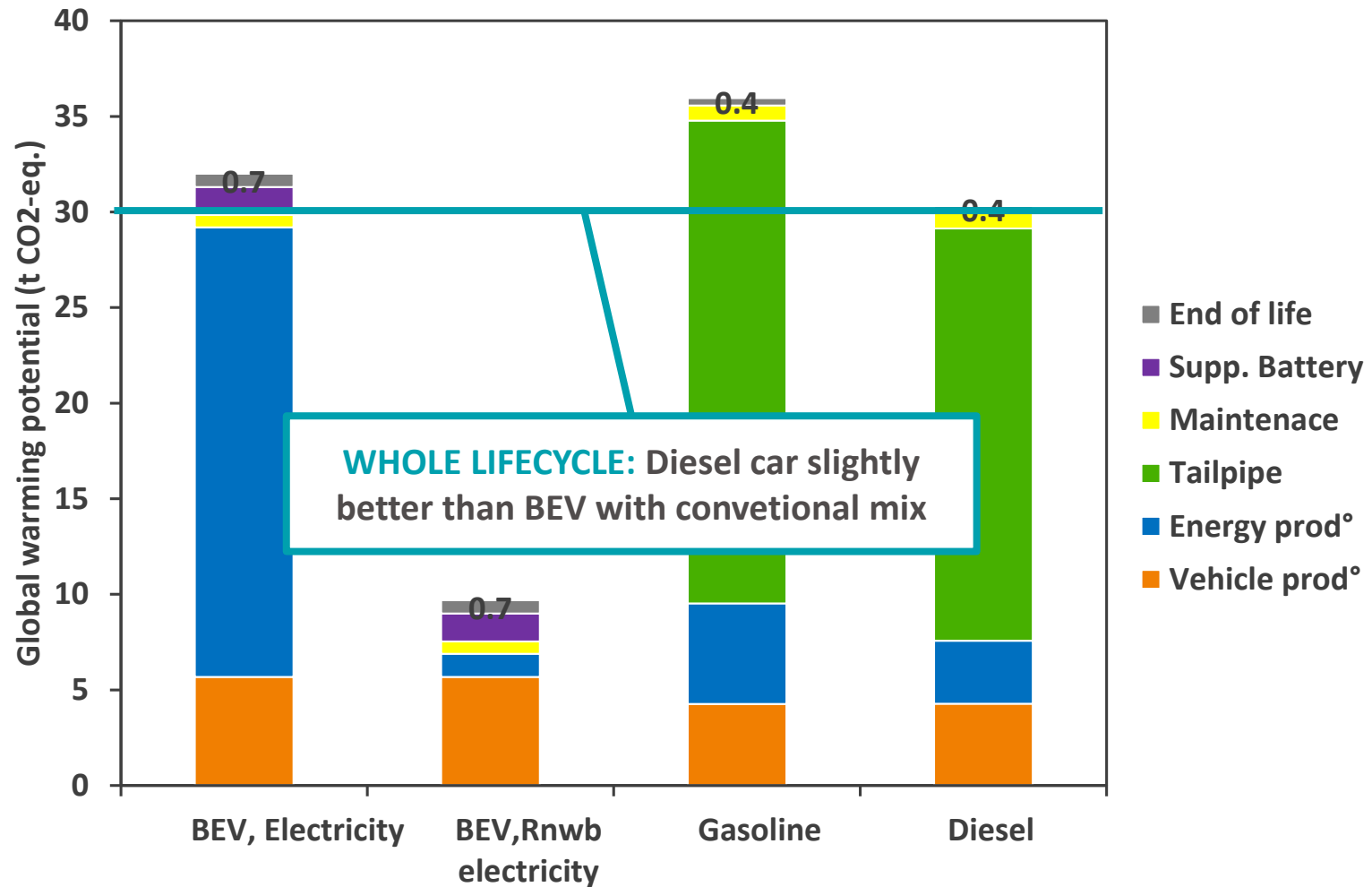
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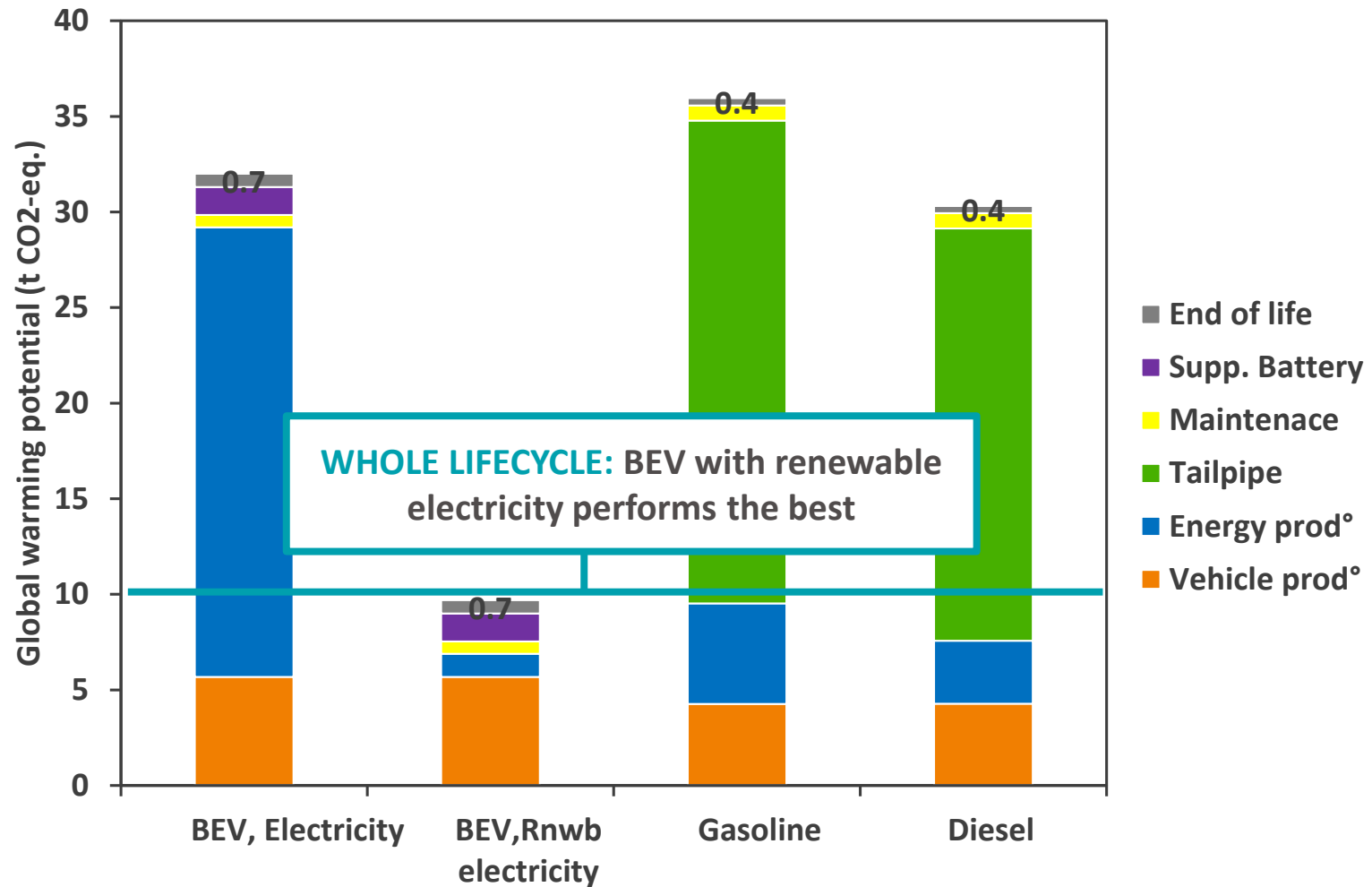
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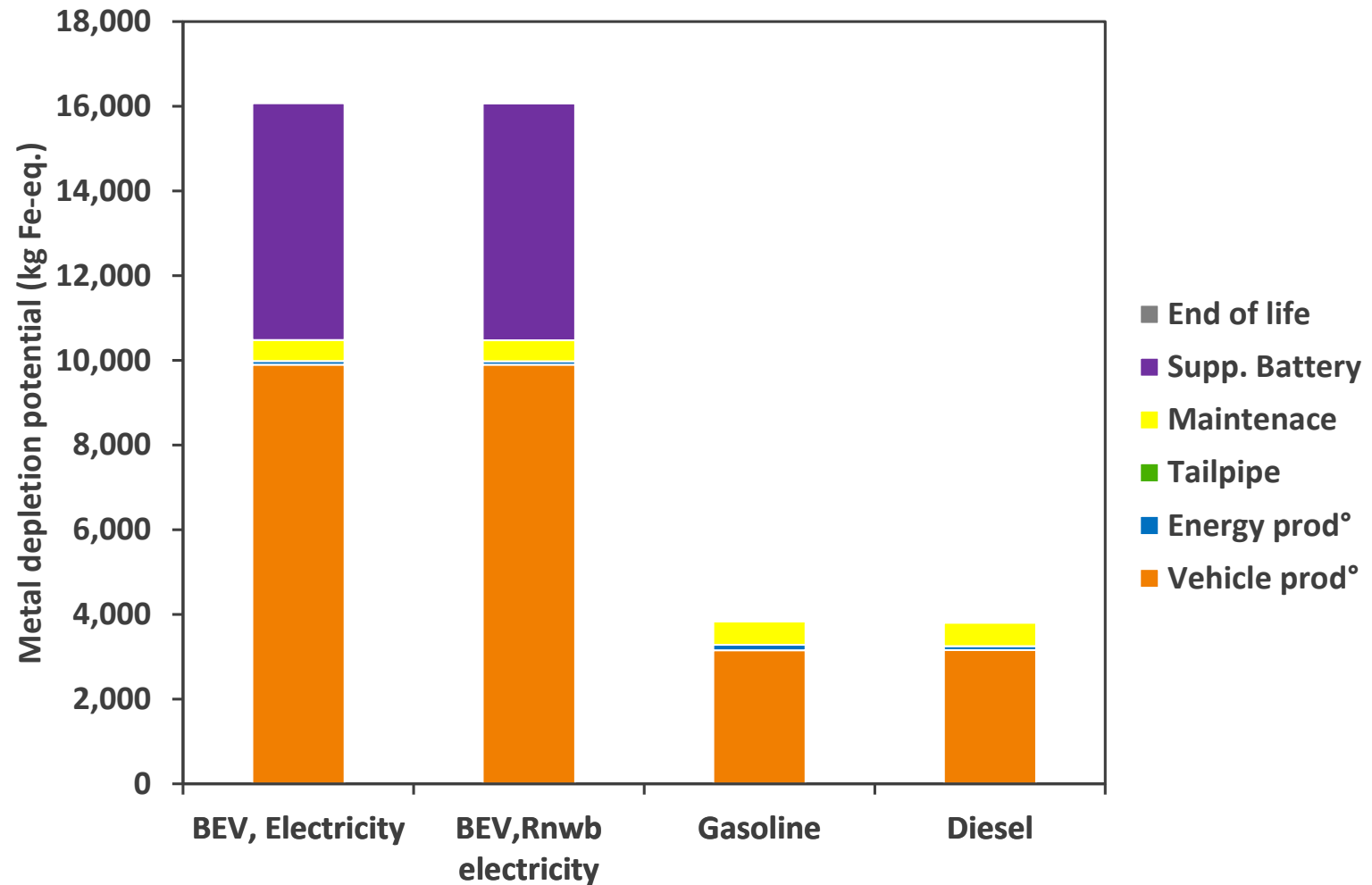
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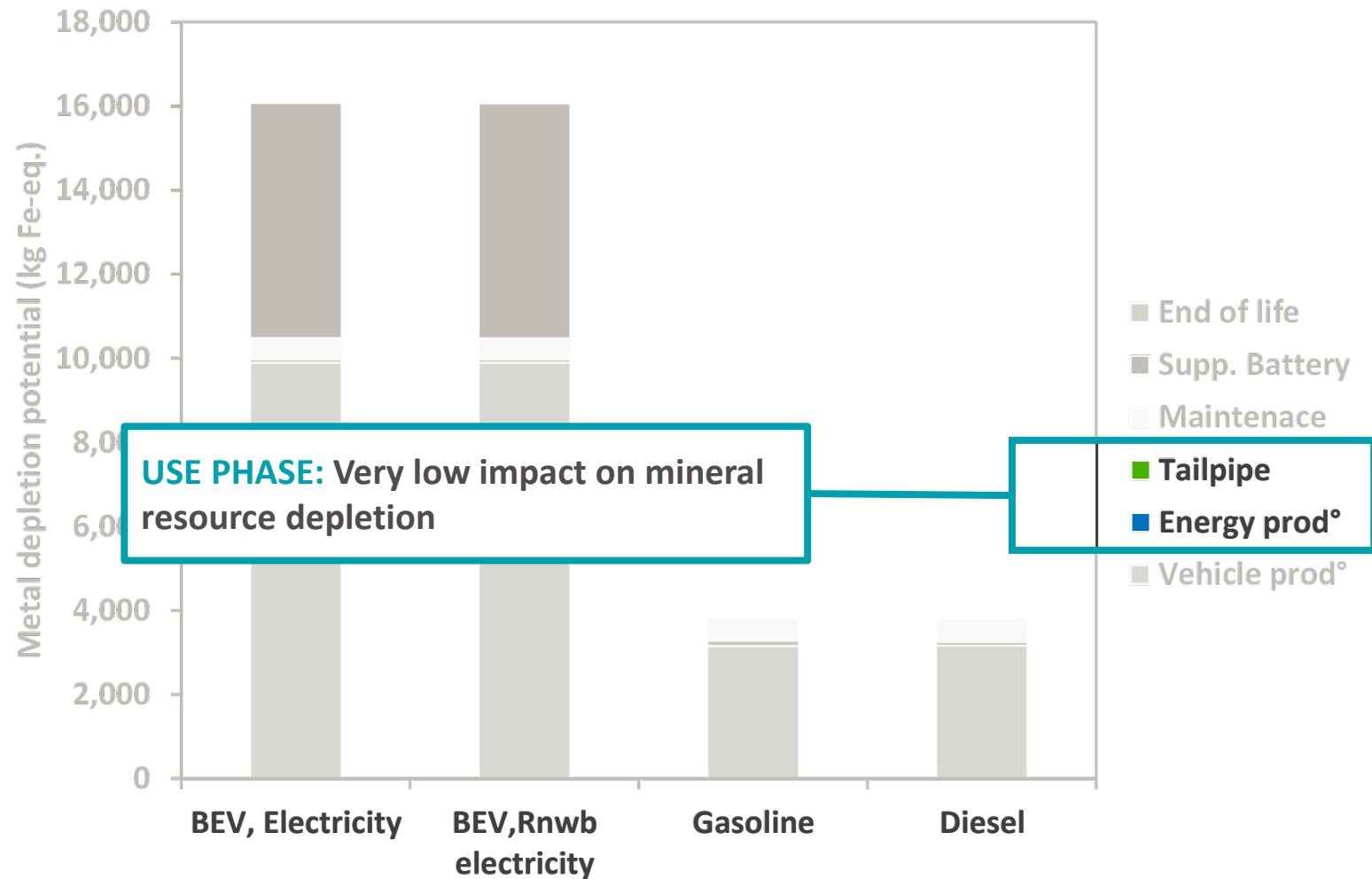
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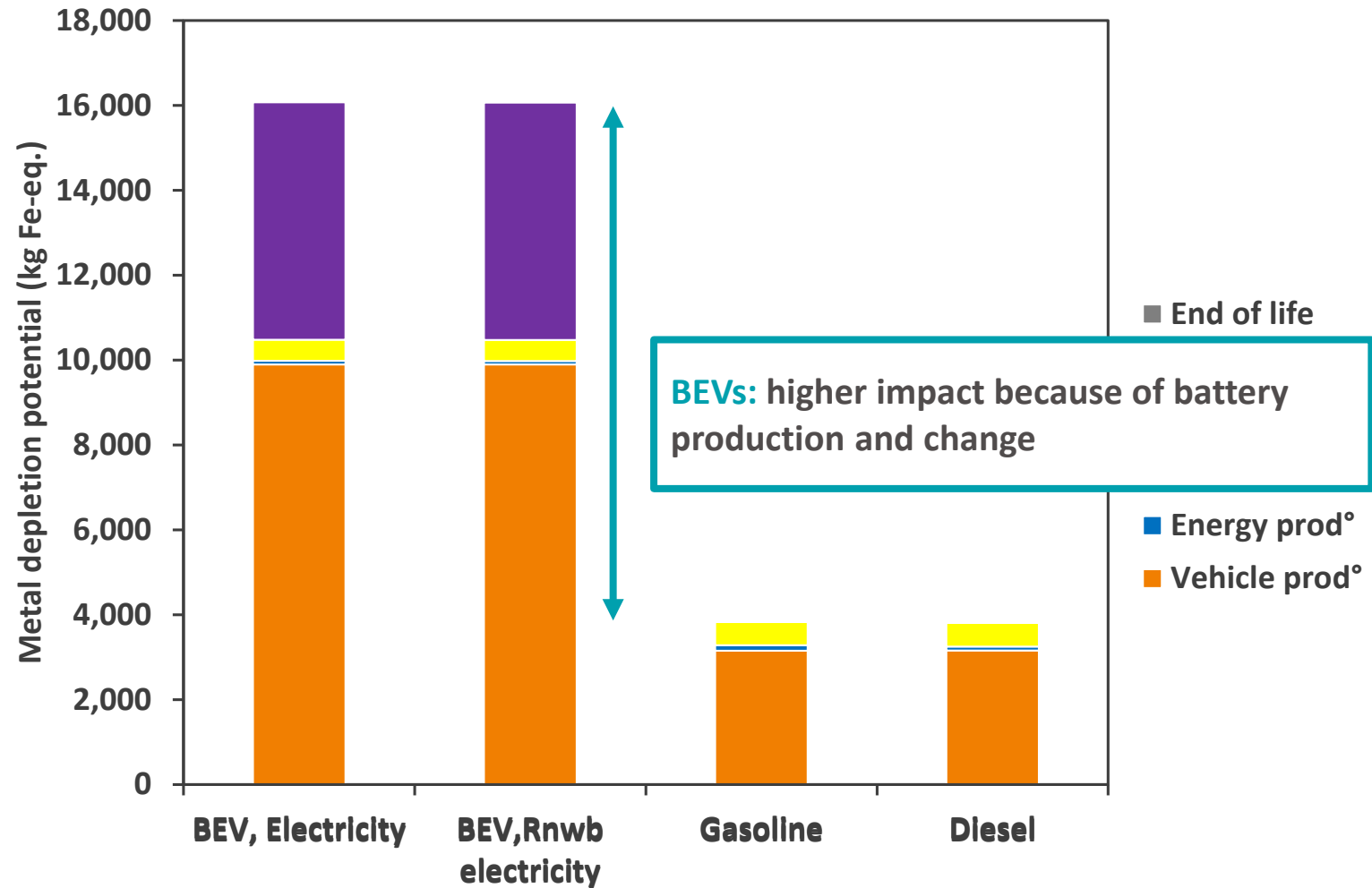
MDP, 150 000 KM, , URBAN DRIVING



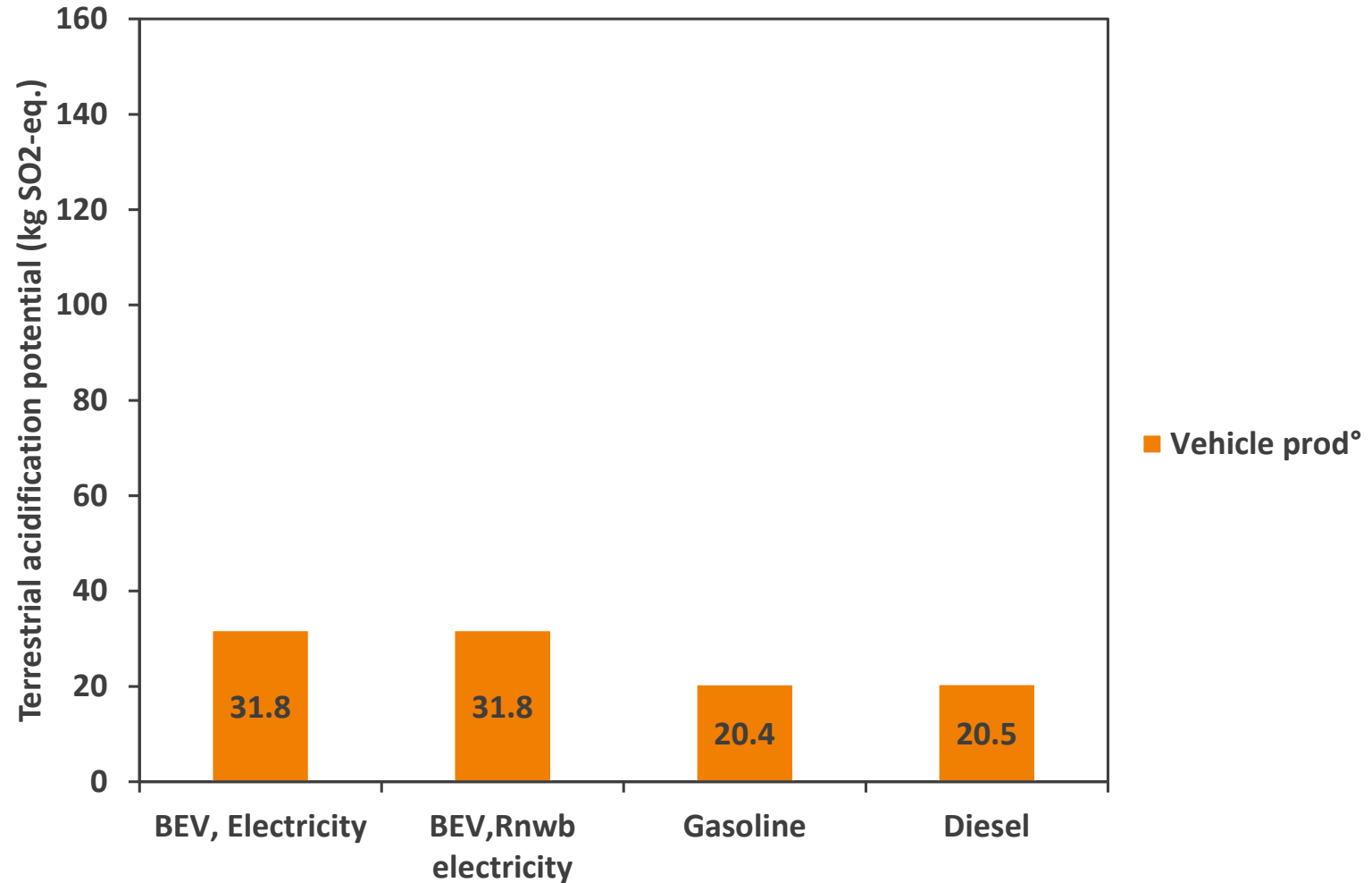
MDP, 150 000 KM, , URBAN DRIVING



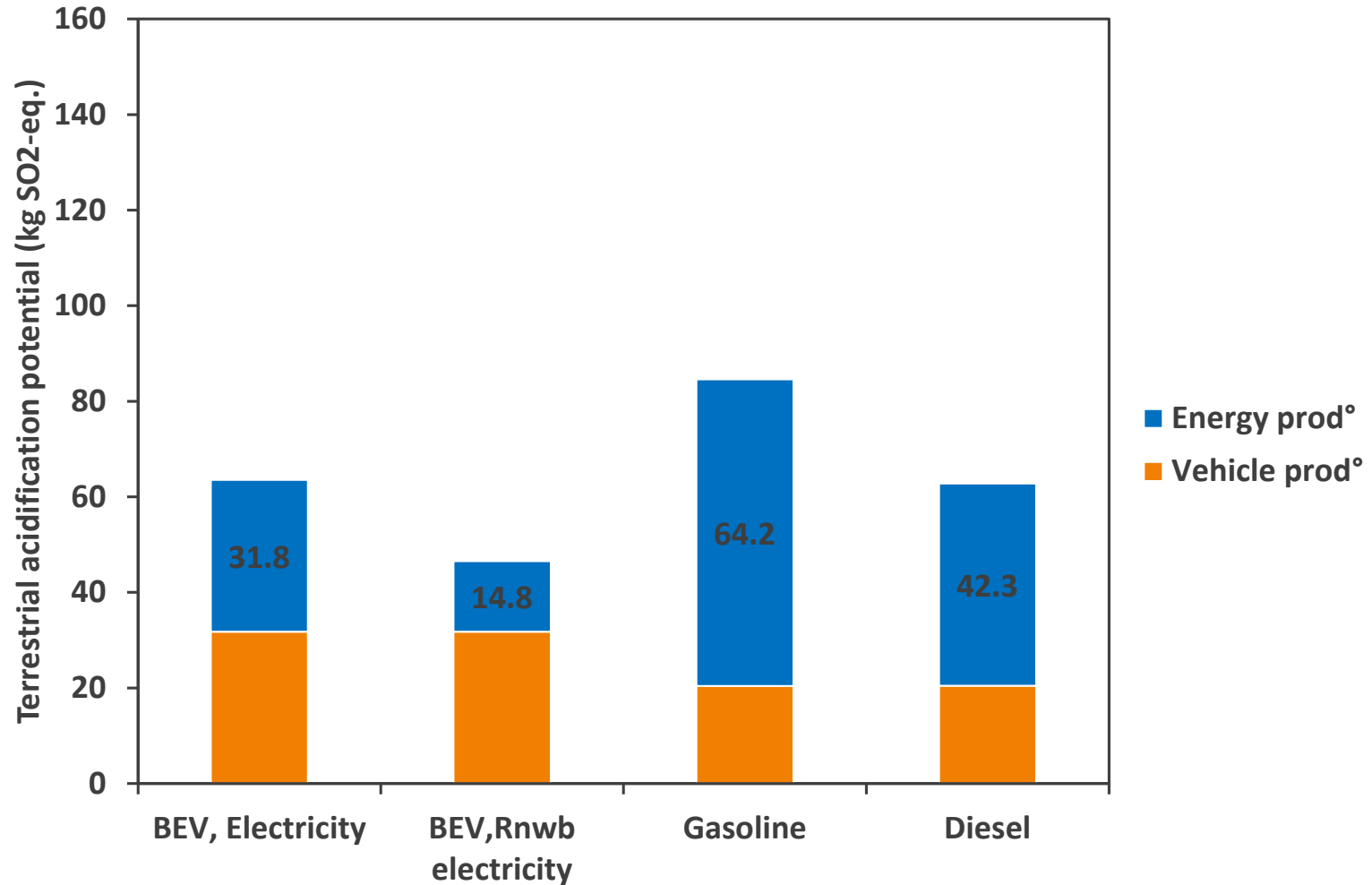
MDP, 150 000 KM, , URBAN DRIVING



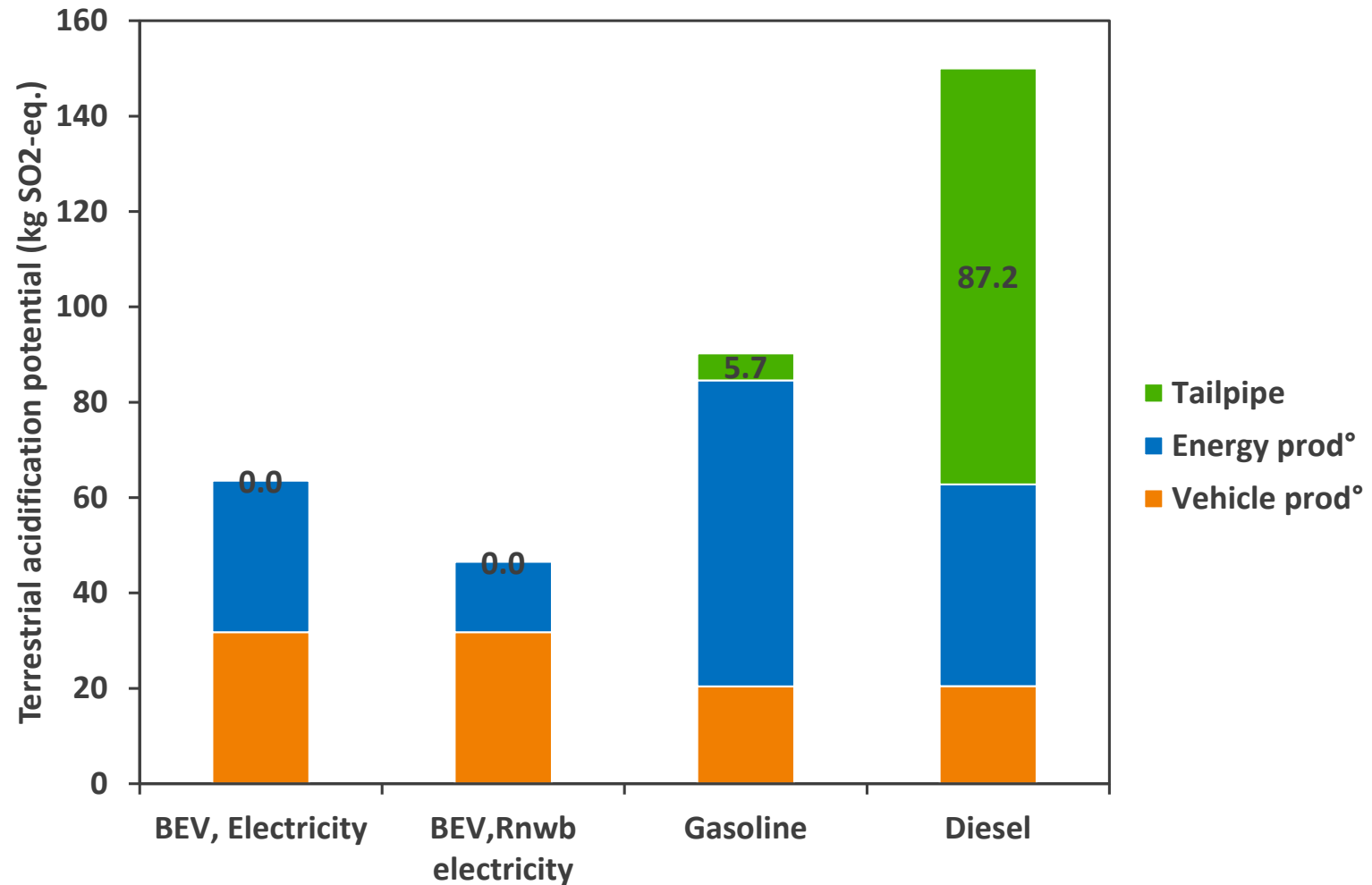
TAP, 150 000 KM, URBAN DRIVING



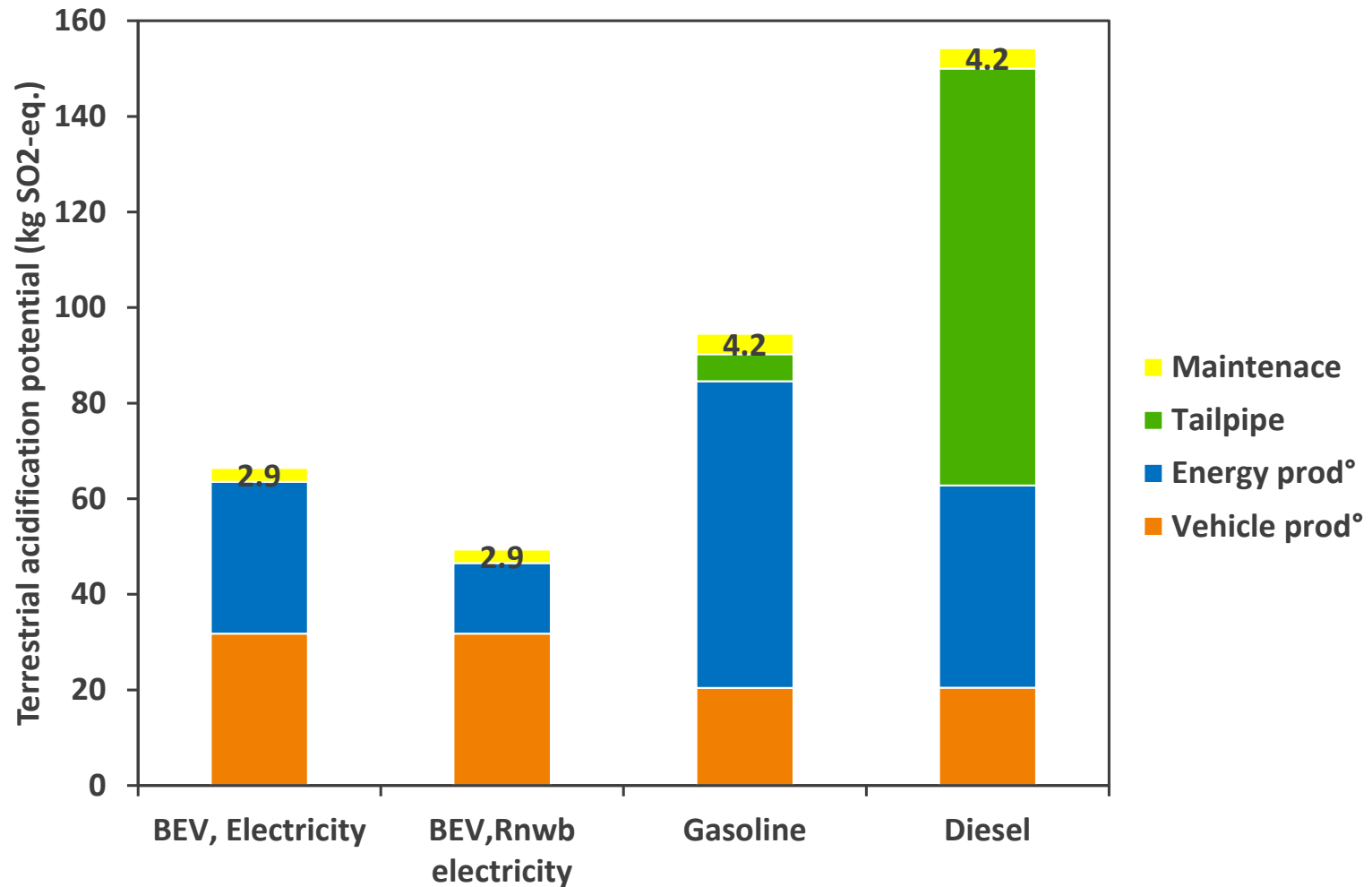
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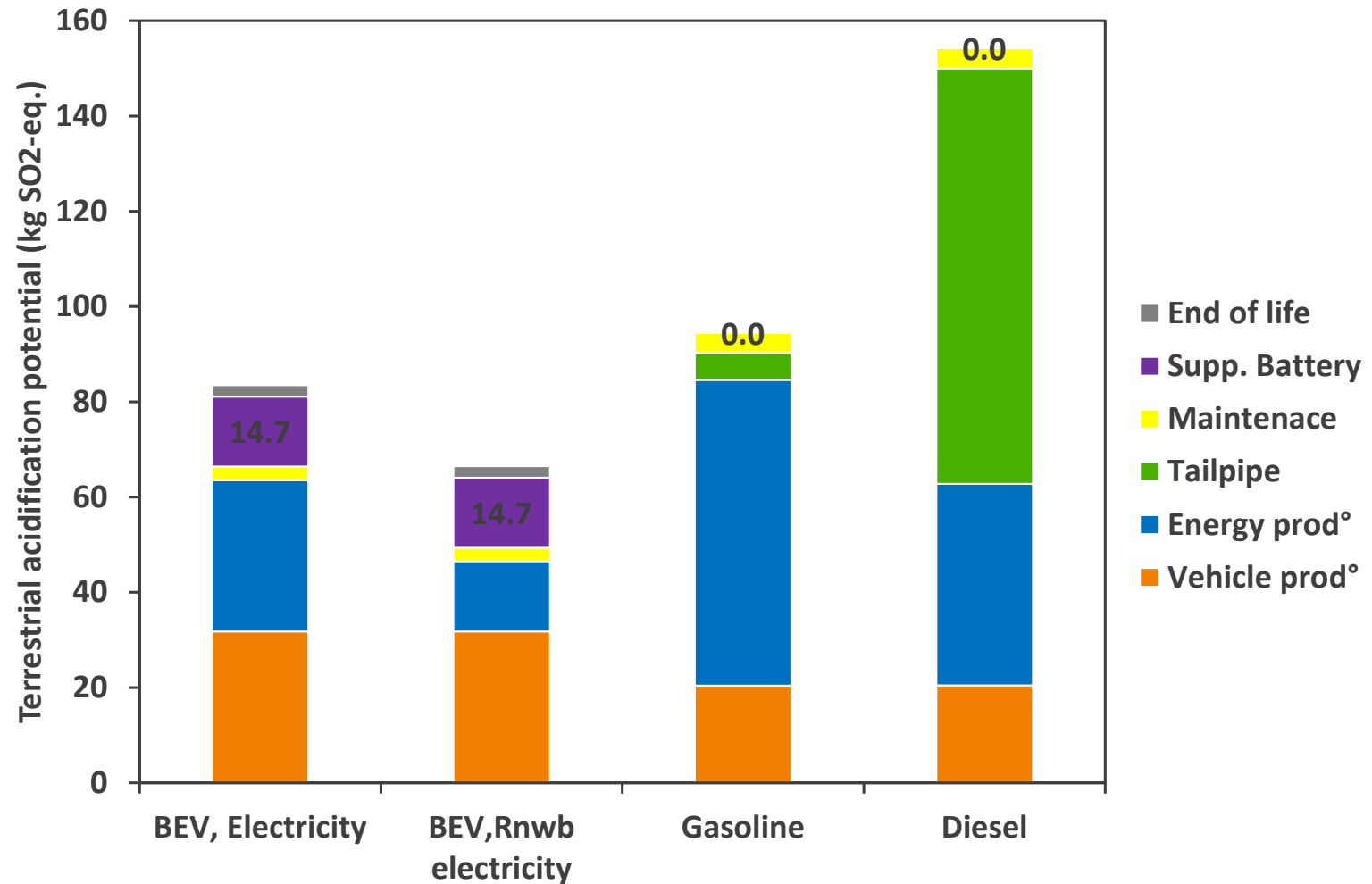
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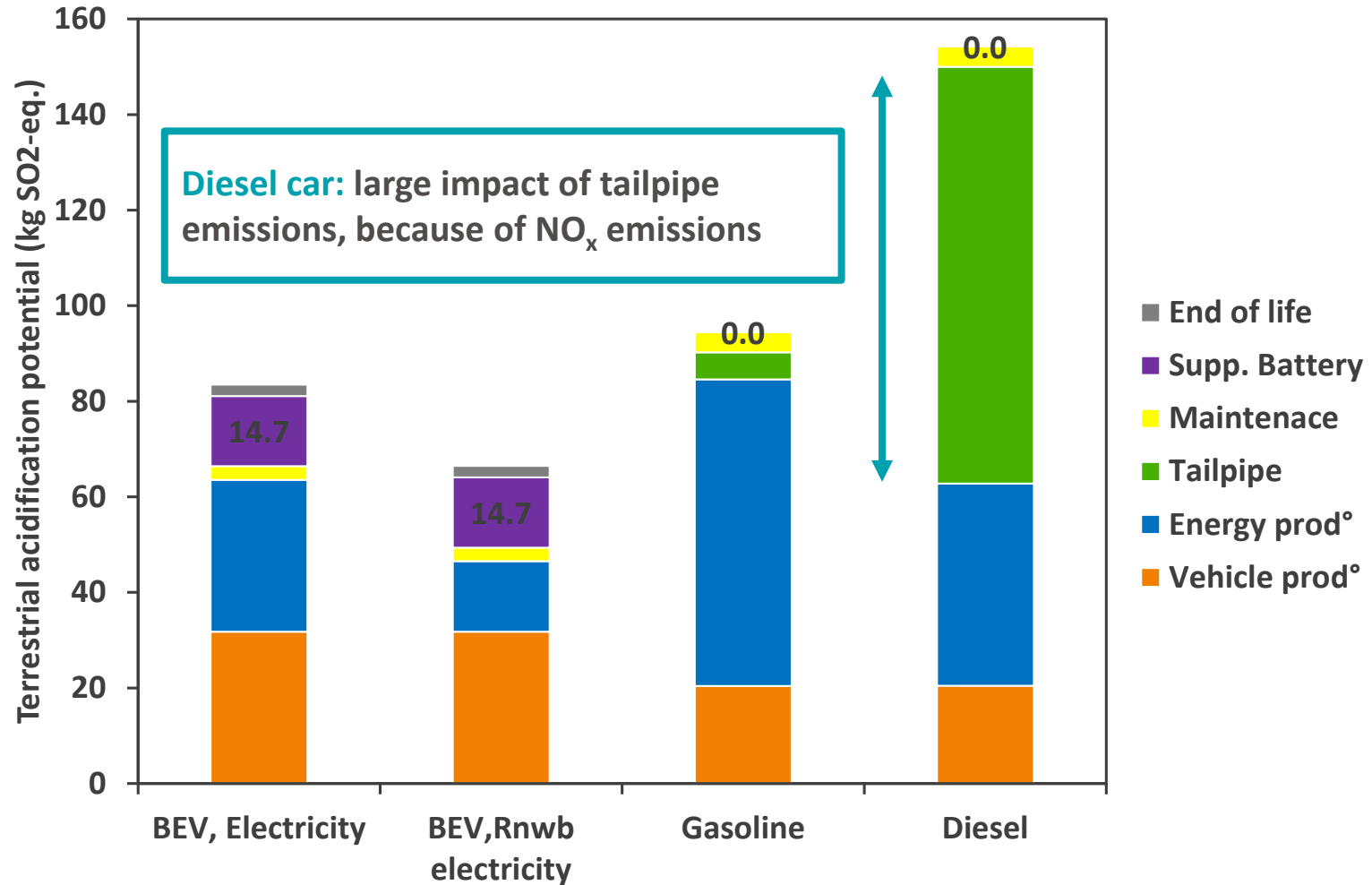
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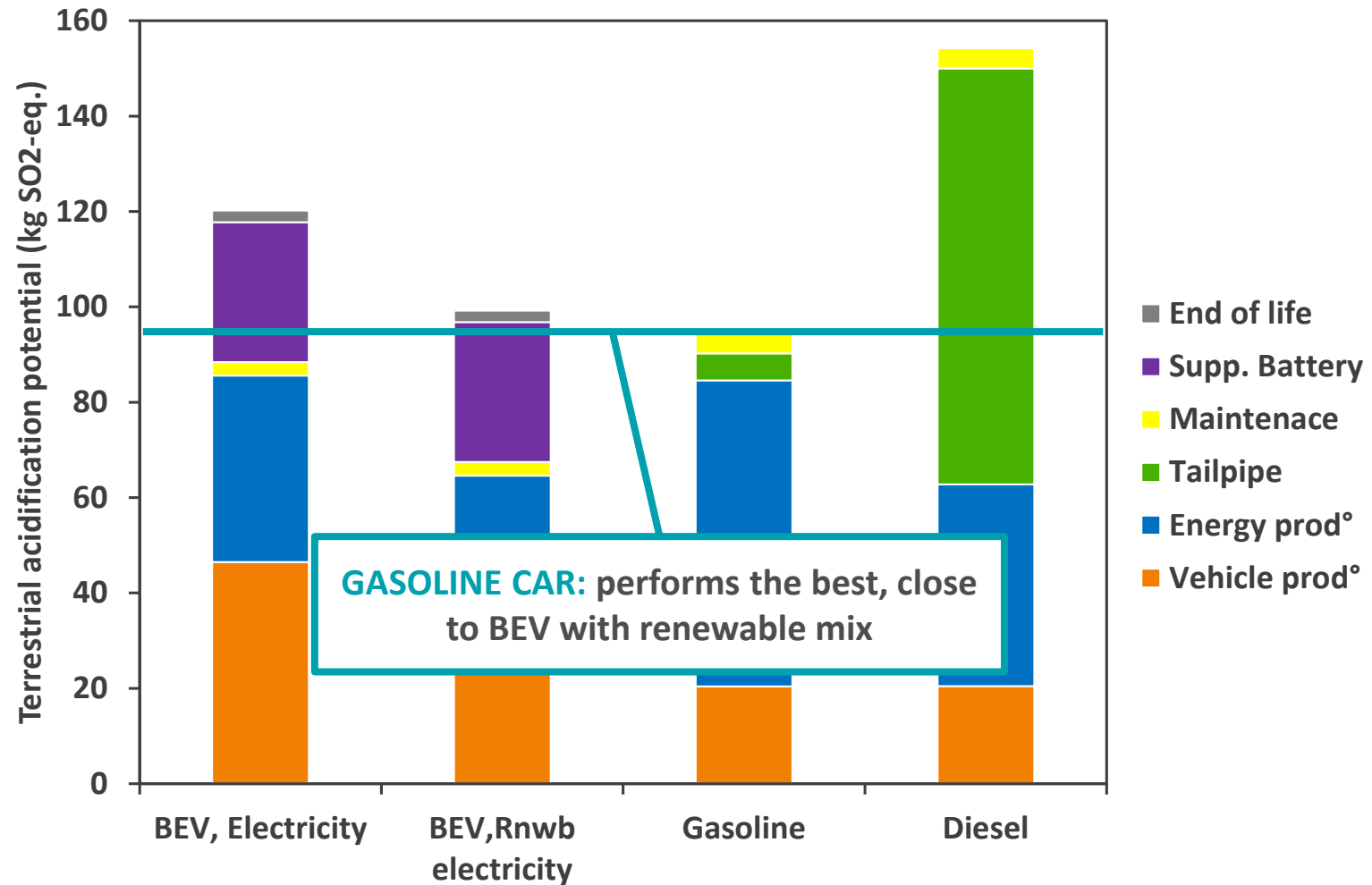
TAP, 150 000 KM, URBAN DRIVING



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→ BATTERY CAPACITY X 2



ISSUE FOR DECISION-MAKERS

PREVIOUS SECTION:

- ✓ **Useful** for automotive engineers.

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× **Do not answer** questions from a policy or decision-making point of view:

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Are electric vehicles « green » at EU scale?

ISSUE FOR DECISION-MAKERS

PREVIOUS SECTION:

✓ **Useful** for automotive engineers.

ISSUE:

× **Do not answer** questions from a policy or decision-making point of view:

Are electric vehicles « green » at EU scale?

What are the impacts of Luxembourgish policies aiming at promoting EVs?

SOLUTION: CONSEQUENTIAL LCA

CONSEQUENTIAL LIFE CYCLE ASSESSMENT (C-LCA):

- Assess the environmental consequences of an action/decision by including market mechanisms into the analysis.

AGENT BASED MODELLING OF LUXEMBOURGISH FLEET:

- Model the current vehicle fleet and market
- Model the effect of the introduction of a new technology (e.g. EVs)
- Model the effect of policies (e.g. incentives, charging infrastructure, etc.)

EXAMPLE FOR MOBILITY: AGENT-BASED MODELLING

AGENT

Social ch.

Economic ch.

Mobility needs

Feelings towards Evs & PHEVs

Behaviour

Etc.



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CAR

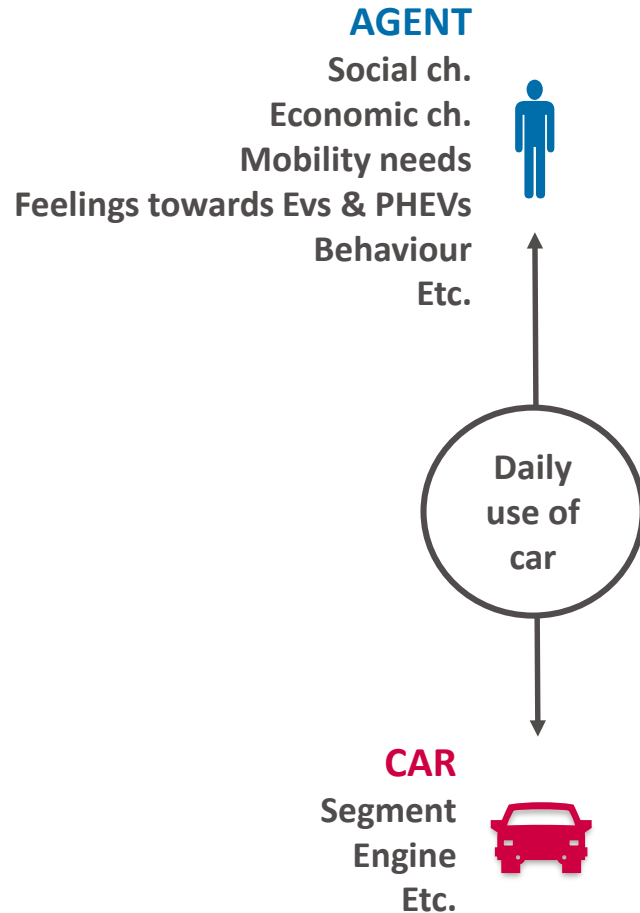
Segment

Engine

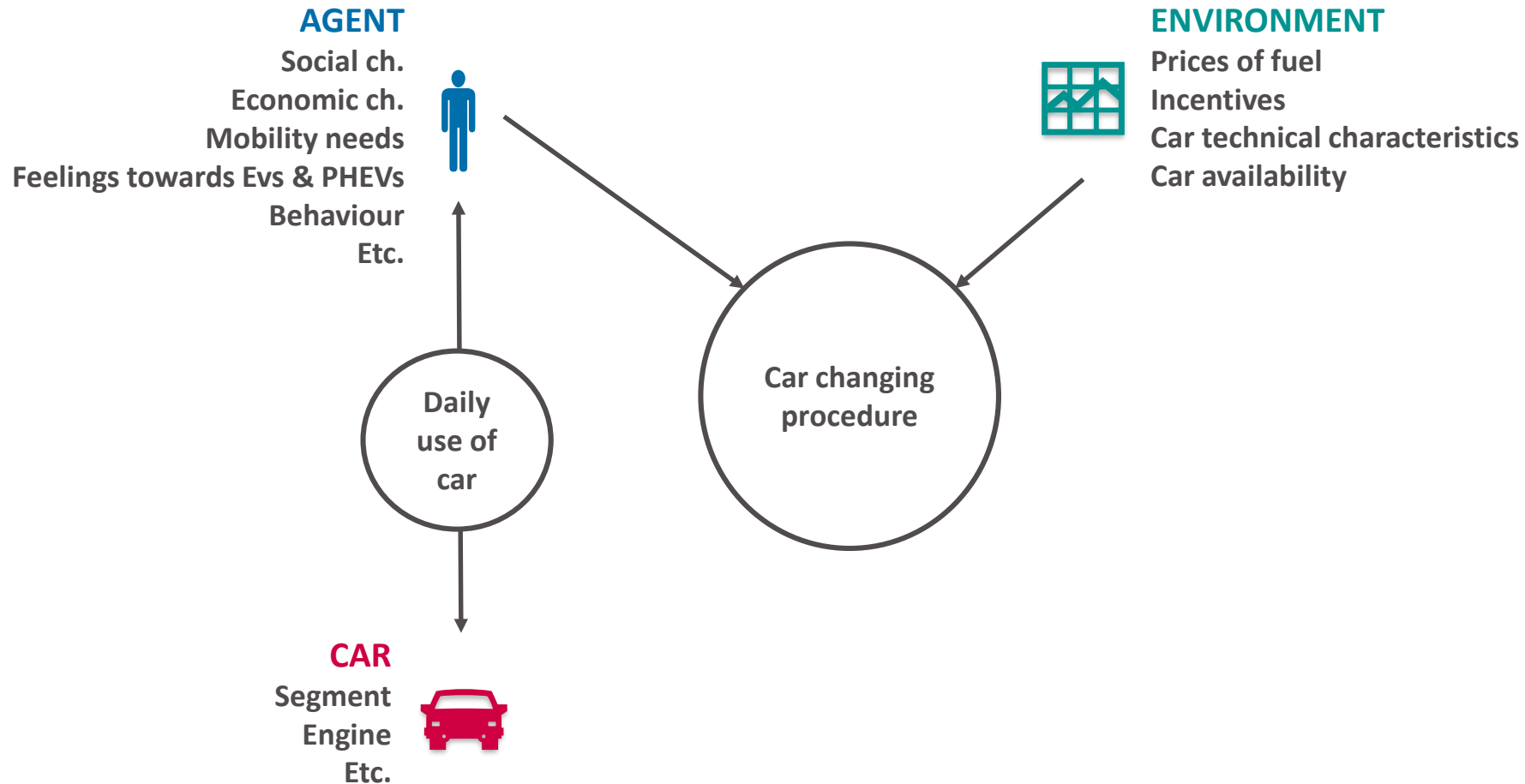
Etc.



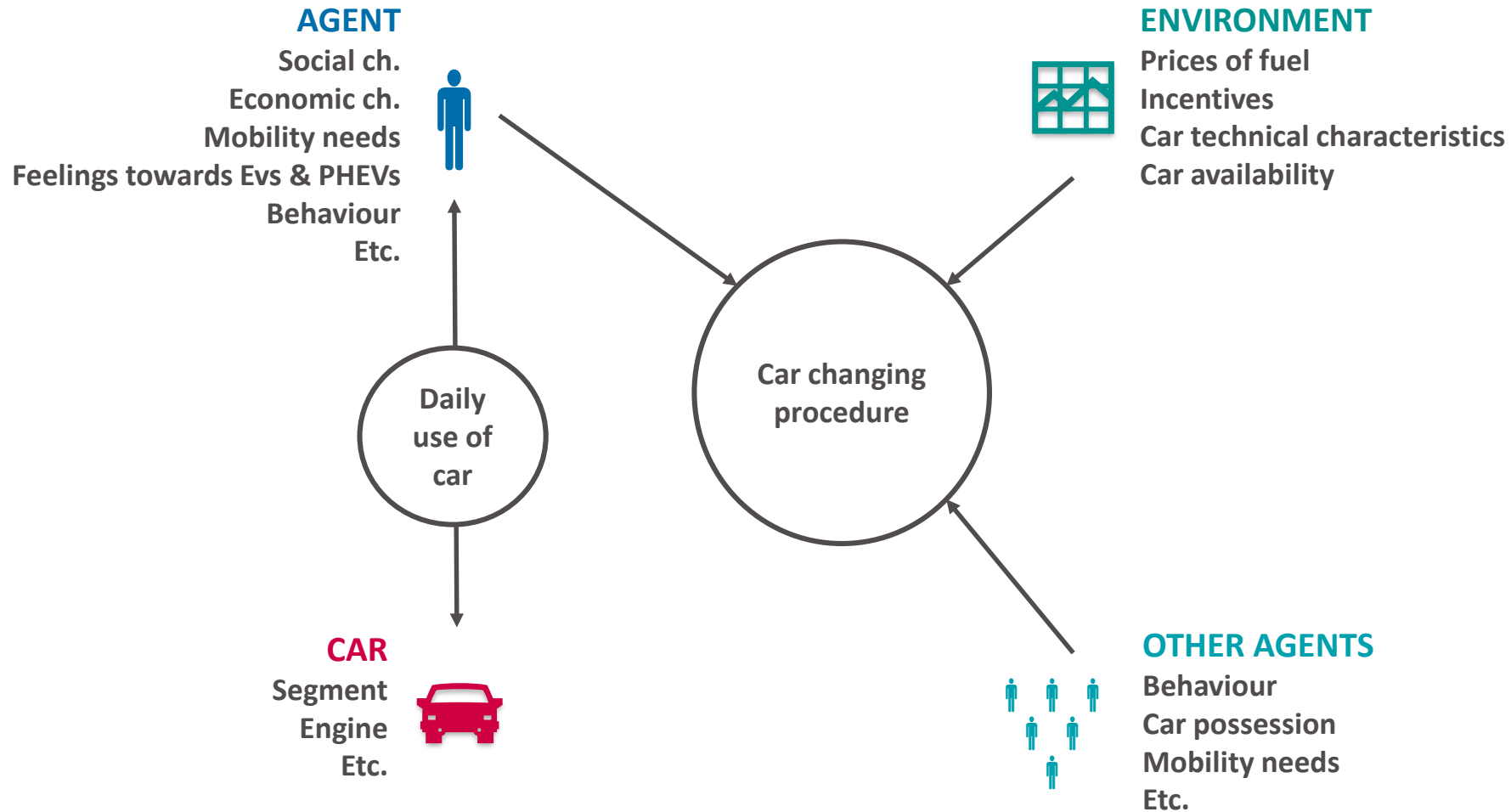
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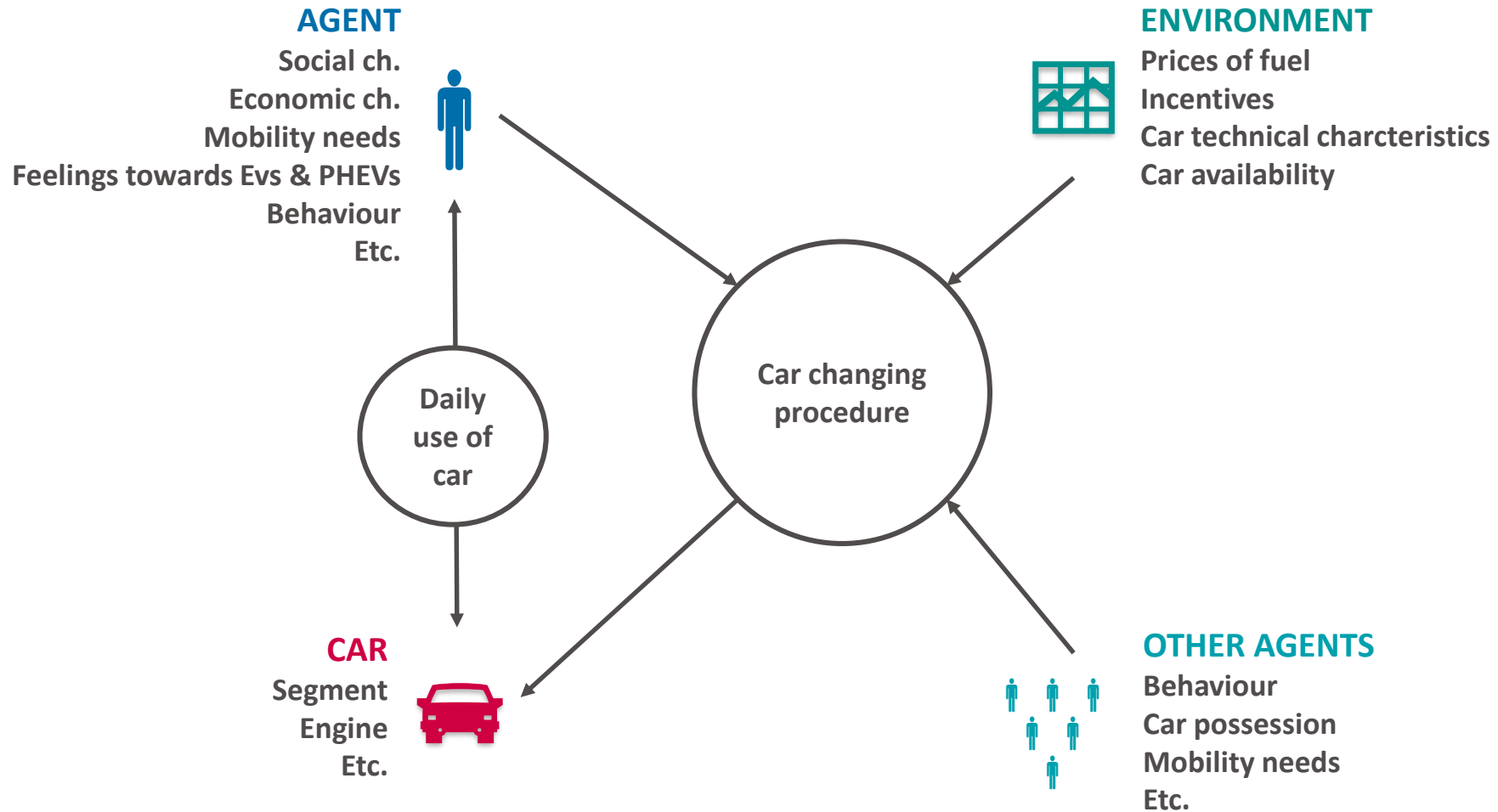
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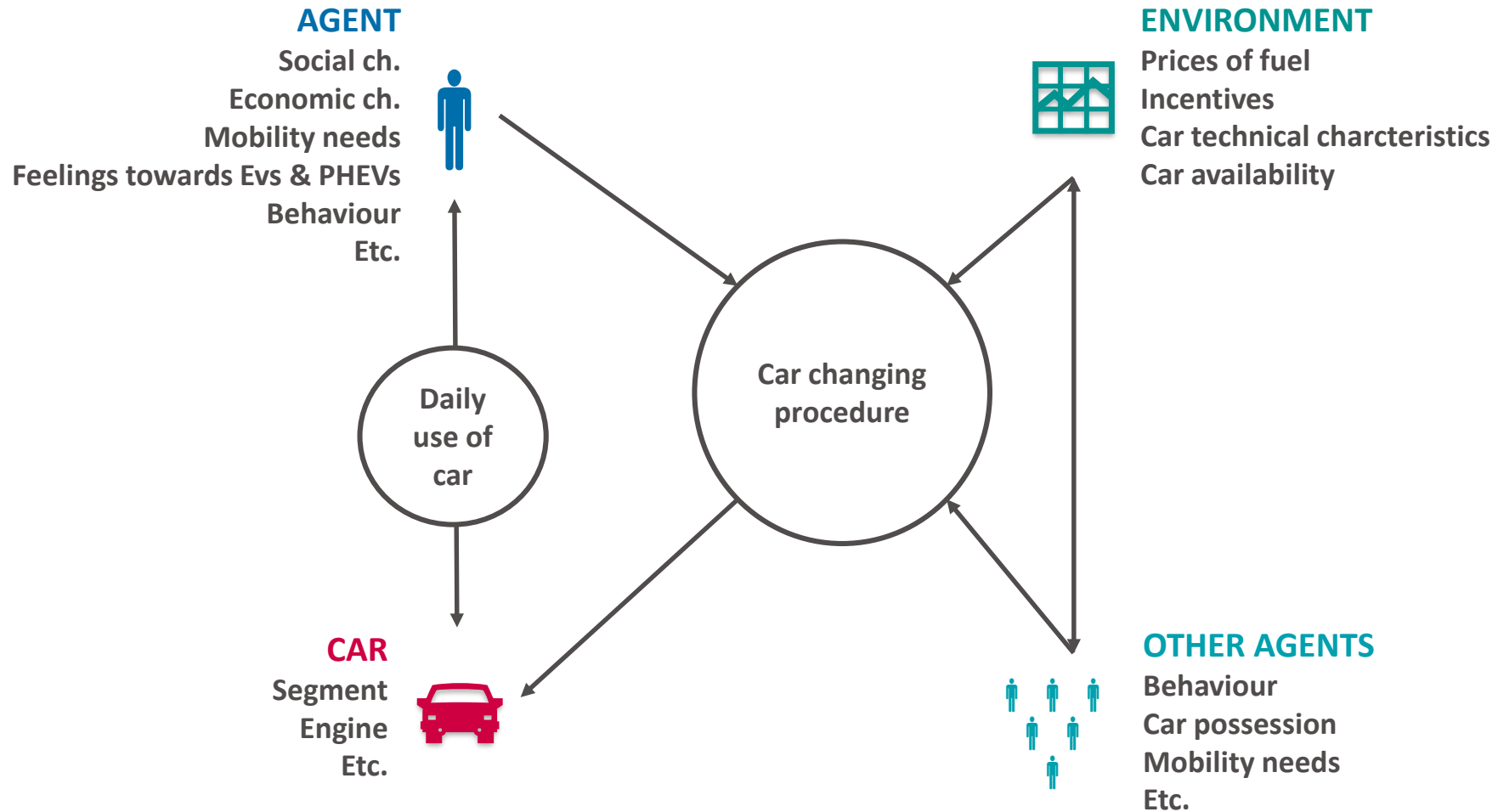
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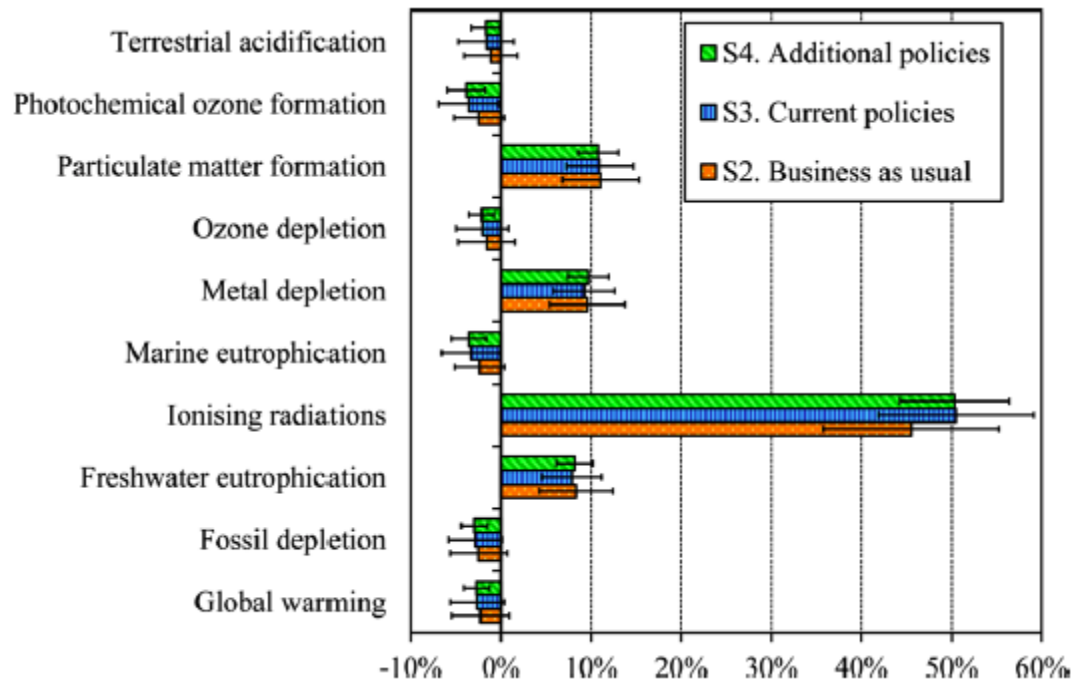
EXAMPLE FOR MOBILITY: AGENT-BASED MODELLING



HELCAR (AFR PDR – DR. FLORENT QUERINI 2013-2014)

Policy scenarios (simulation from 2013 to 2020), Luxembourg fleet

- *S1: No EVs*
- *S2_ Business as usual: no more CAR-e from 2015, limited deployment of charging infrastructure (only 10% of users can charge their vehicle at work)*
- *S3: Current policy: no more CAR-e and 50% user can charge at work*
- *S4: Additional policy: same than above but CAR-e is maintained*



HEL CAR (AFR PDR – DR. FLORENT QUERINI 2013-2014)

Recommandations

- **Have larger infrastructure deployment.** The very uncertain nature of EV deployment leads to high uncertainties on the environmental consequences,
- **Extend the lifetime of batteries**, by for instance promoting their reuse in other applications before dismantling and recycling.
- Considering the results obtained for the German mix, we would recommend to Luxembourg's stakeholders to **keep the renewable electricity policy**

For further details:



Article

pubs.acs.org/est

Combining Agent-Based Modeling and Life Cycle Assessment for the Evaluation of Mobility Policies

Querini Florent* and Benetto Enrico

Public Research Centre Henri Tudor, 6A Avenue des Hauts-Fourneaux, L-4362 Esch sur Alzette, Luxembourg

CONNECTING

FNR CORE (2015-2018) – LIST, LISER and TU Eindhoven

Objectives

- Develop a proof of concept tool to account for the consequential environmental effects, (from a lifecycle perspective) of policy actions promoting **multimodal e-mobility**, combining Agent Based Modelling and Life Cycle Assessment capabilities.
- Case study: daily commuters from France to Kirchberg

Scenarios:

- *Business as usual (baseline): most plausible hypothesis for the next years*
- *Green: policies in favour of sustainable development are strengthened*
- *Economic downturn: economic crisis with increasing prices will promote policy measures aimed at increasing purchasing power rather than sustainable development*
- *Non coherent policies: specific case of cross border commuters e.g. Luxembourg prone to green scenario and Lorraine adopts economic downturn scenario*

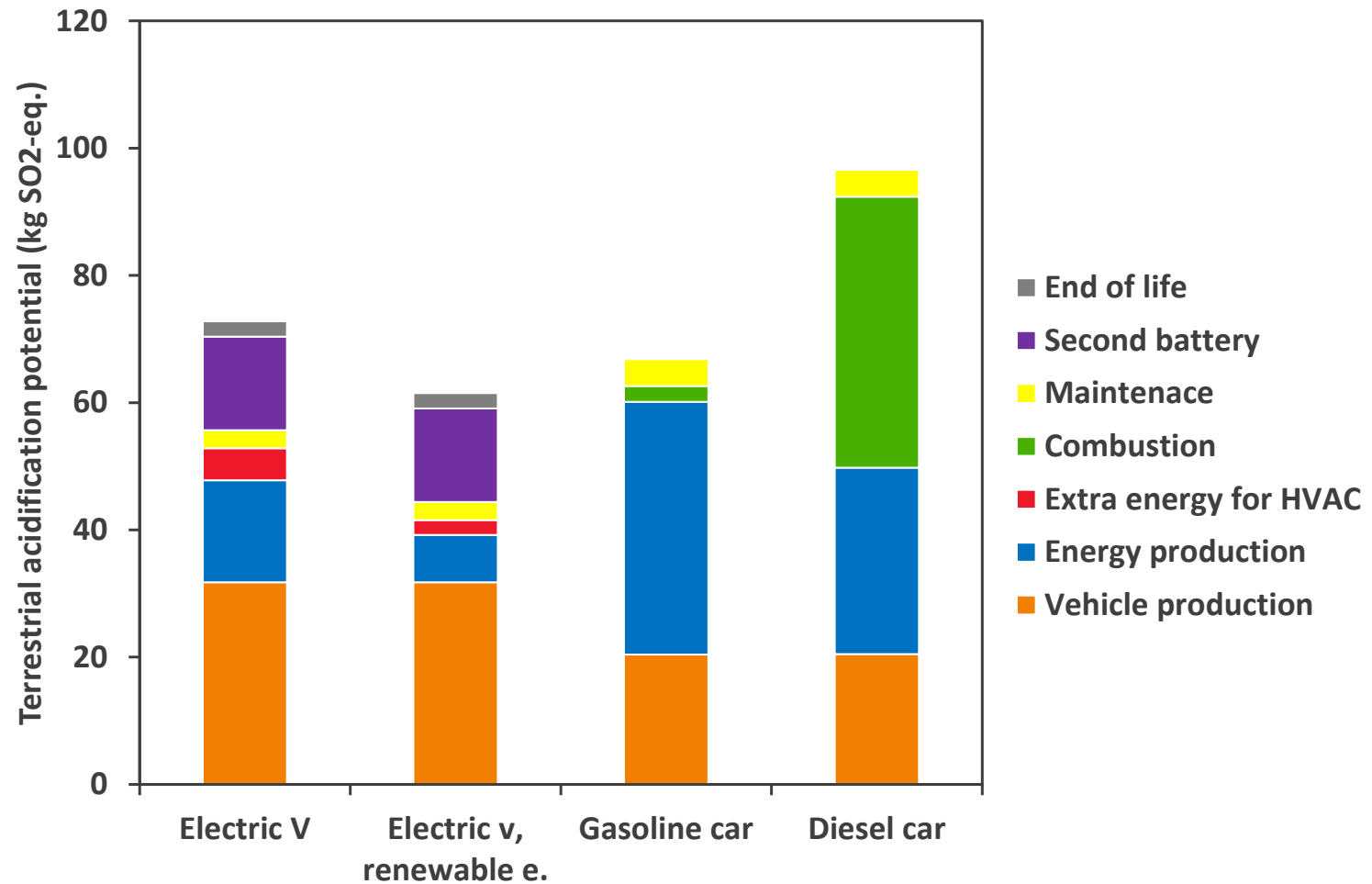
Stakeholders workshop on November, 20th to validate and improve the scenarios

THANK YOU FOR YOUR ATTENTION

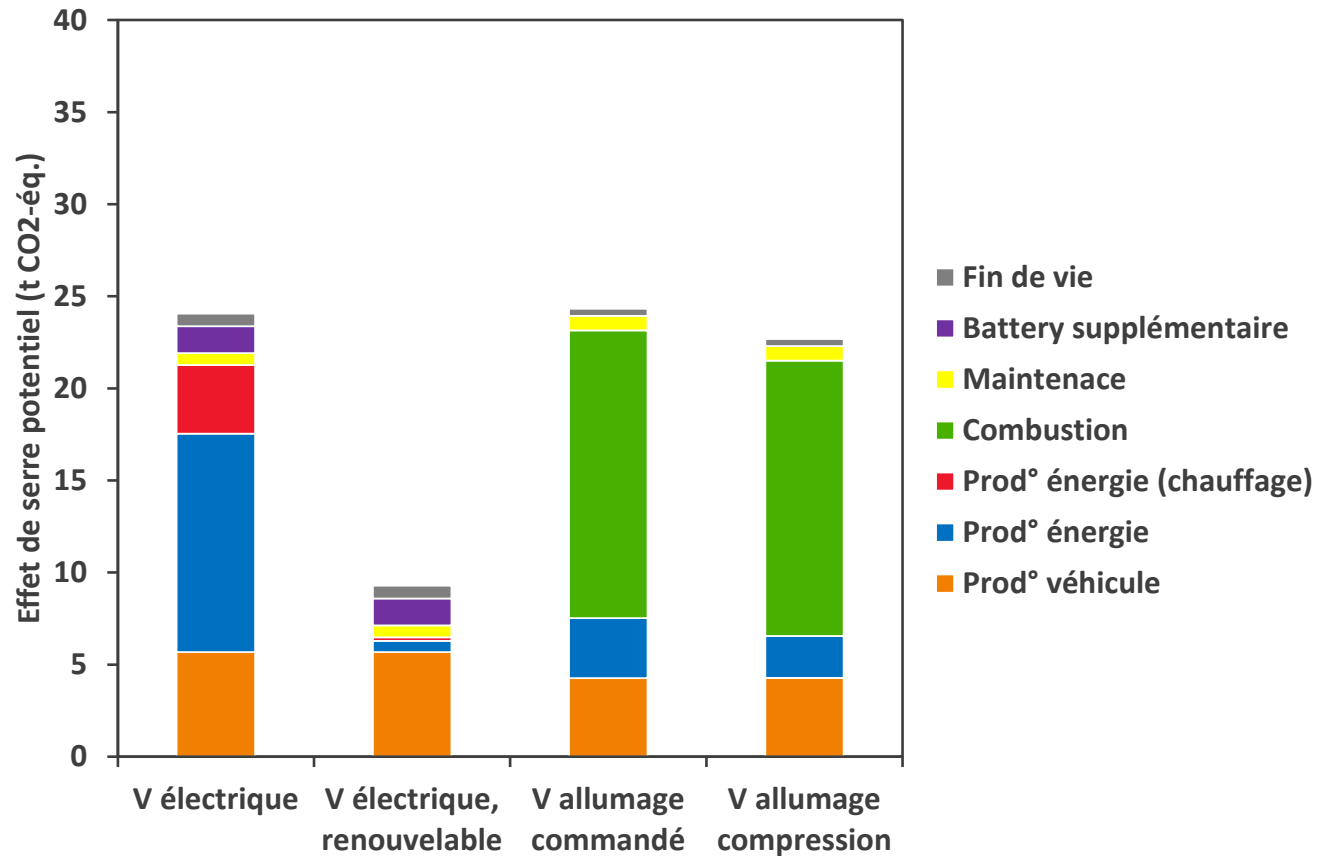
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TAP WITH ROAD CYCLE



GWP WITH ROAD CYCLE



GWP WITH HIGHWAY CYCLE

