MATERIA NOVA Materials R&D Center

Environmental Life Cycle Assessment in GRASS project

Olivier Talon

Final Event Interreg FWVL GRASS

16/06/2022 - Ghent

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What is LCA?

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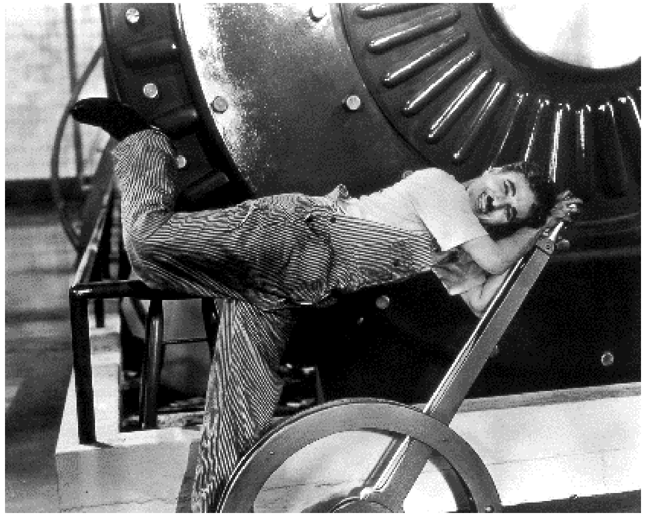
LCA identifies all steps of the life cycle of the studied system

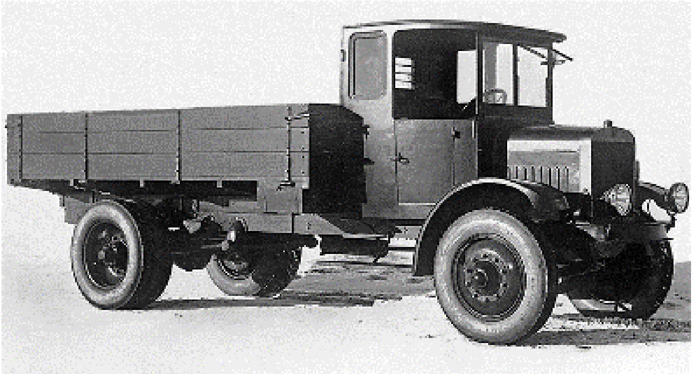
end of life treatment



transports

manufacture of the product

raw materials extraction



use phase

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LCA quantifies exchanges between the system and the environment

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LCA makes links between these exchanges and multiple environmental impact categories

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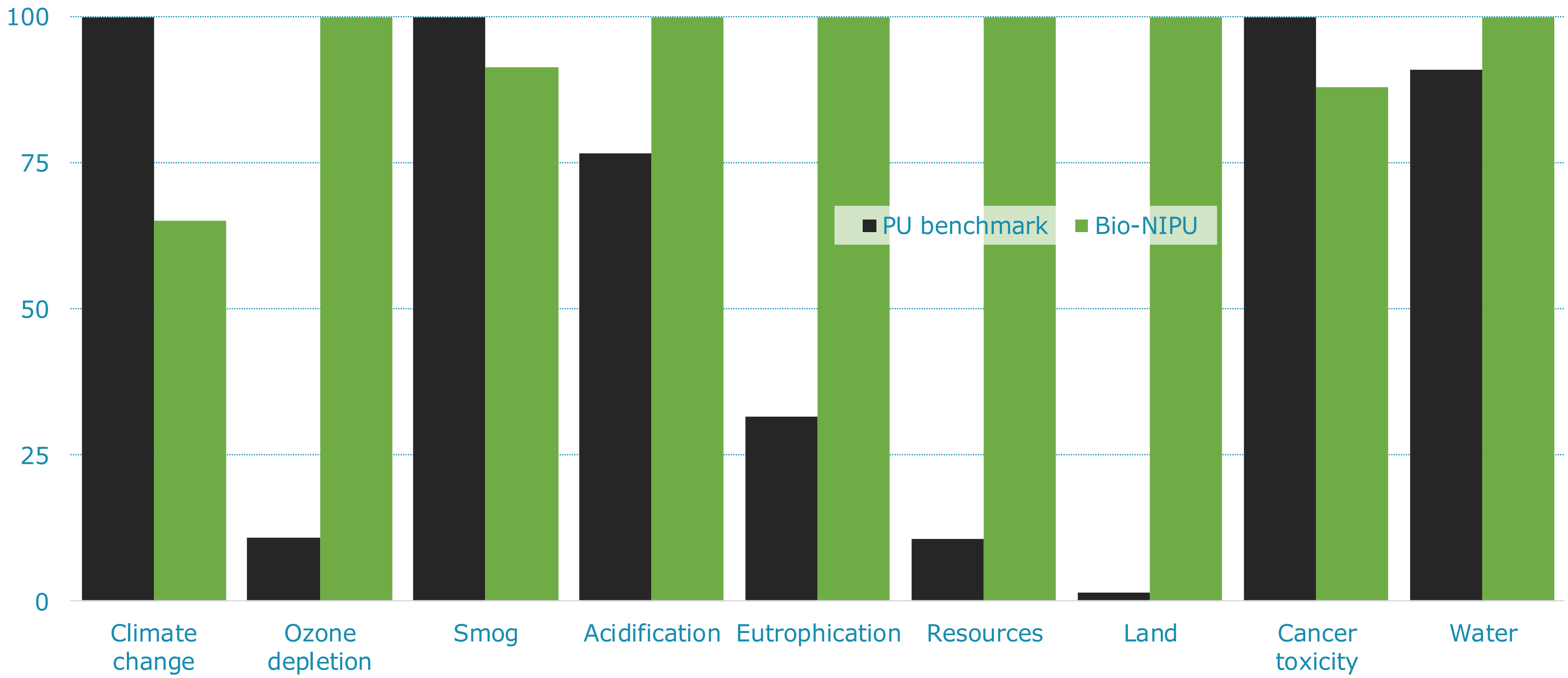
LCA translates these flows into environmental impacts



Results of the CO2Green project financed by Région Wallonne

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LCA compares systems based on the same functionality

1 kg paint A vs. 1 kg paint B

cover 1 m² wall with paint A or B for 3 years

(includes lifetime, amount of paint, painting step...)

FUNCTIONAL UNIT

What do we use LCA for in GRASS?

- identify the main contributors to the environmental impacts of artificial turf
- evaluate the environmental consequences of a potential fire of artificial turf
- evaluate the environmental benefits of fireproofing artificial turf
- identify potential environmental hotsposts of the fireproofing strategy (and provide ecodesign advice for optimization)

What do we **not** use LCA for in GRASS?

- ~~compare artificial turf with other systems for similar applications~~

This enables us to simplify study and reduce the system boundaries

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LCA in GRASS

Model of the reference system

Global turf structure

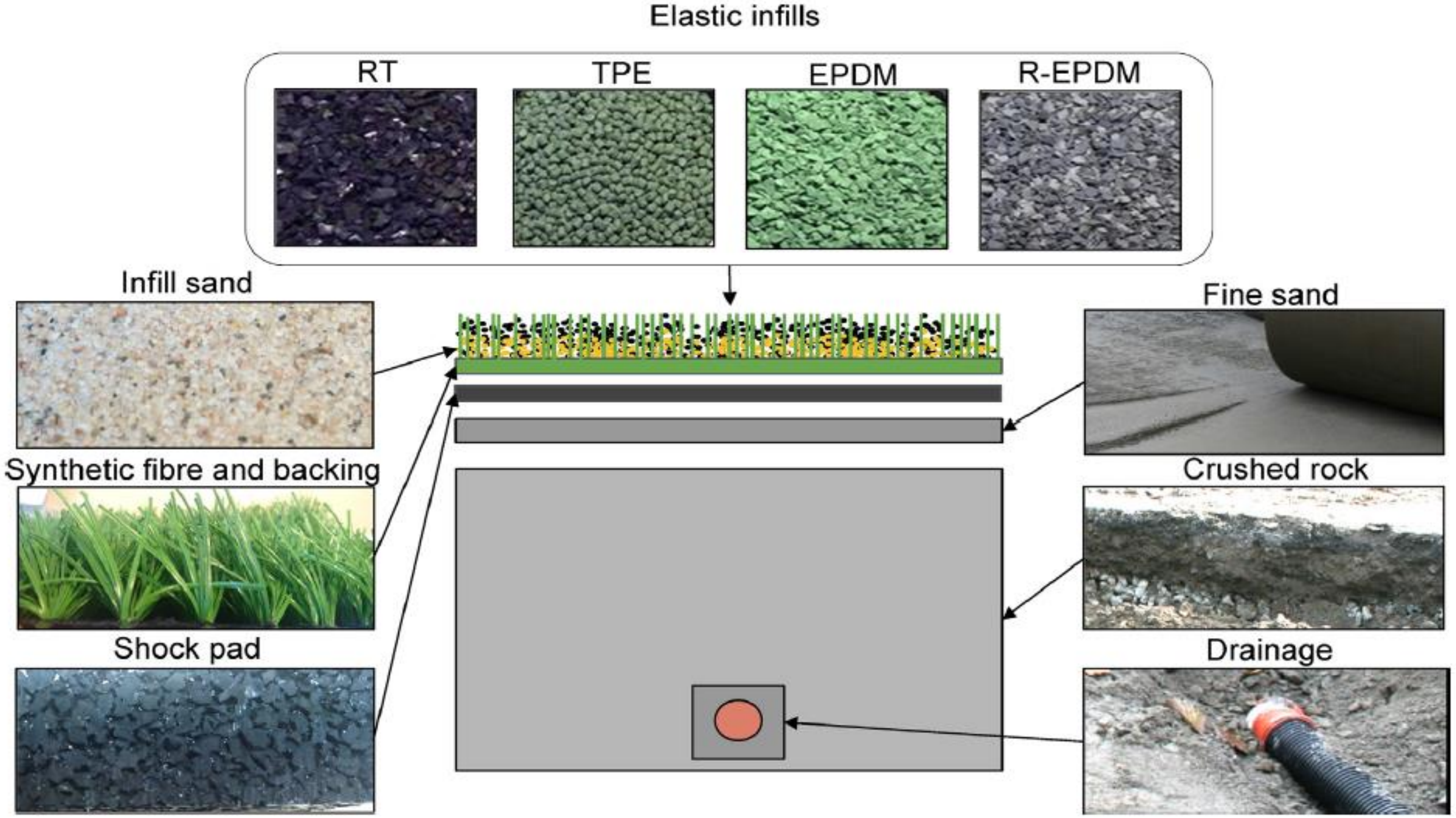

Fig. 1. Design of artificial turf fields. Pictures produced by the article authors. Illustration based on Simpson et al. (2013).

Source Magnusson 2017

Model of the reference system

Reduction of system boundaries

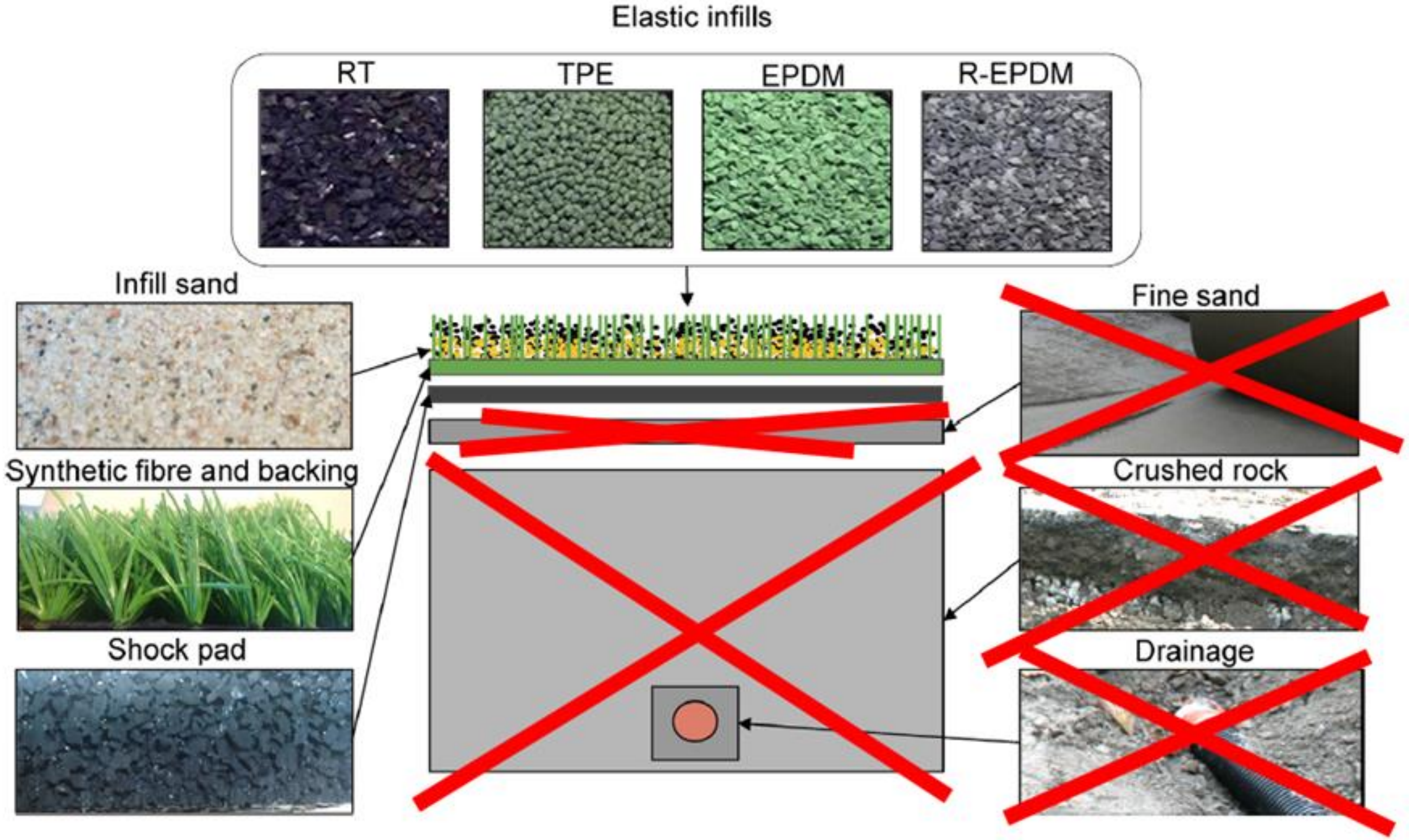

Fig. 1. Design of artificial turf fields. Pictures produced by the article authors. Illustration based on Simpson et al. (2013).

Modelling life cycle inventories

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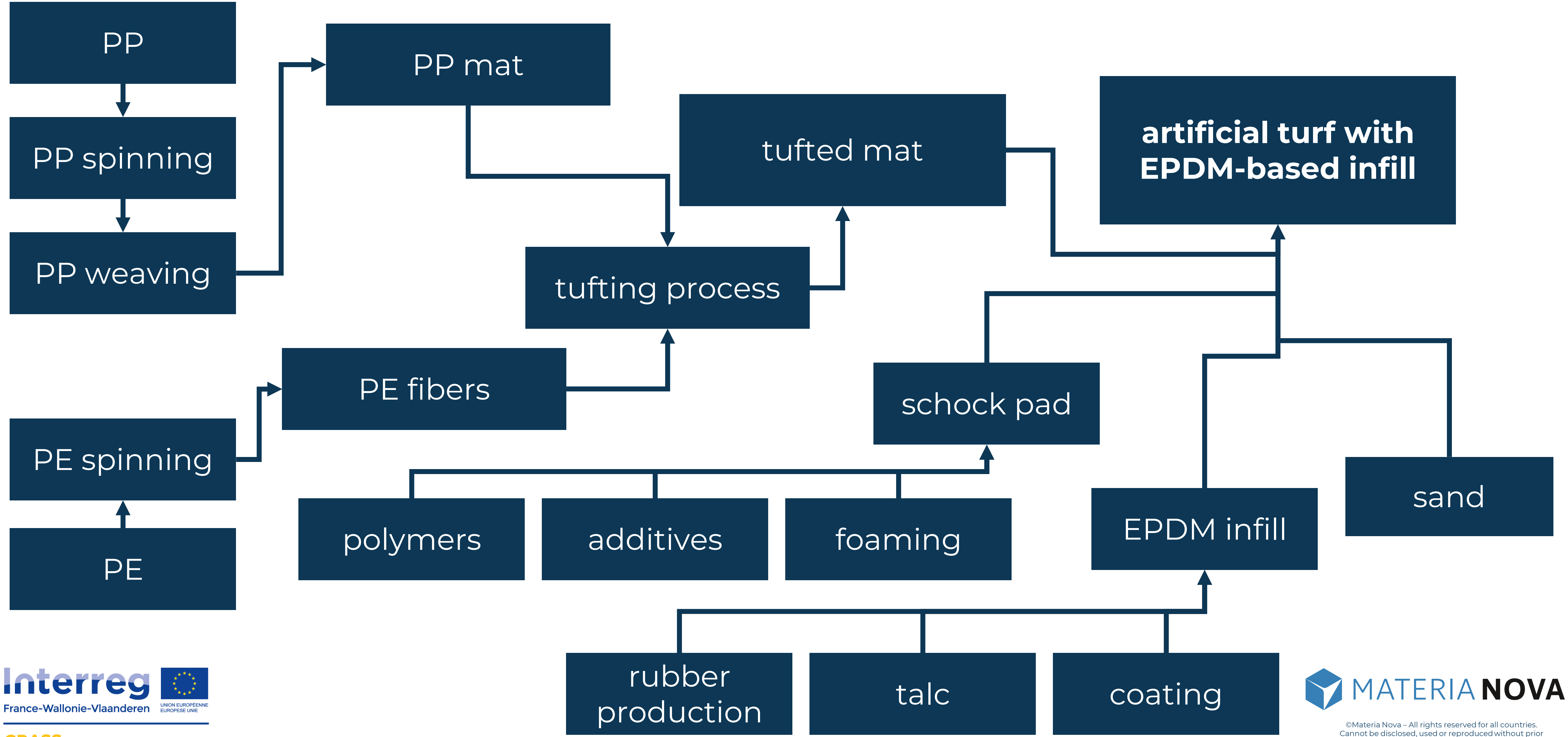
Process tree – reference turf for outdoor use



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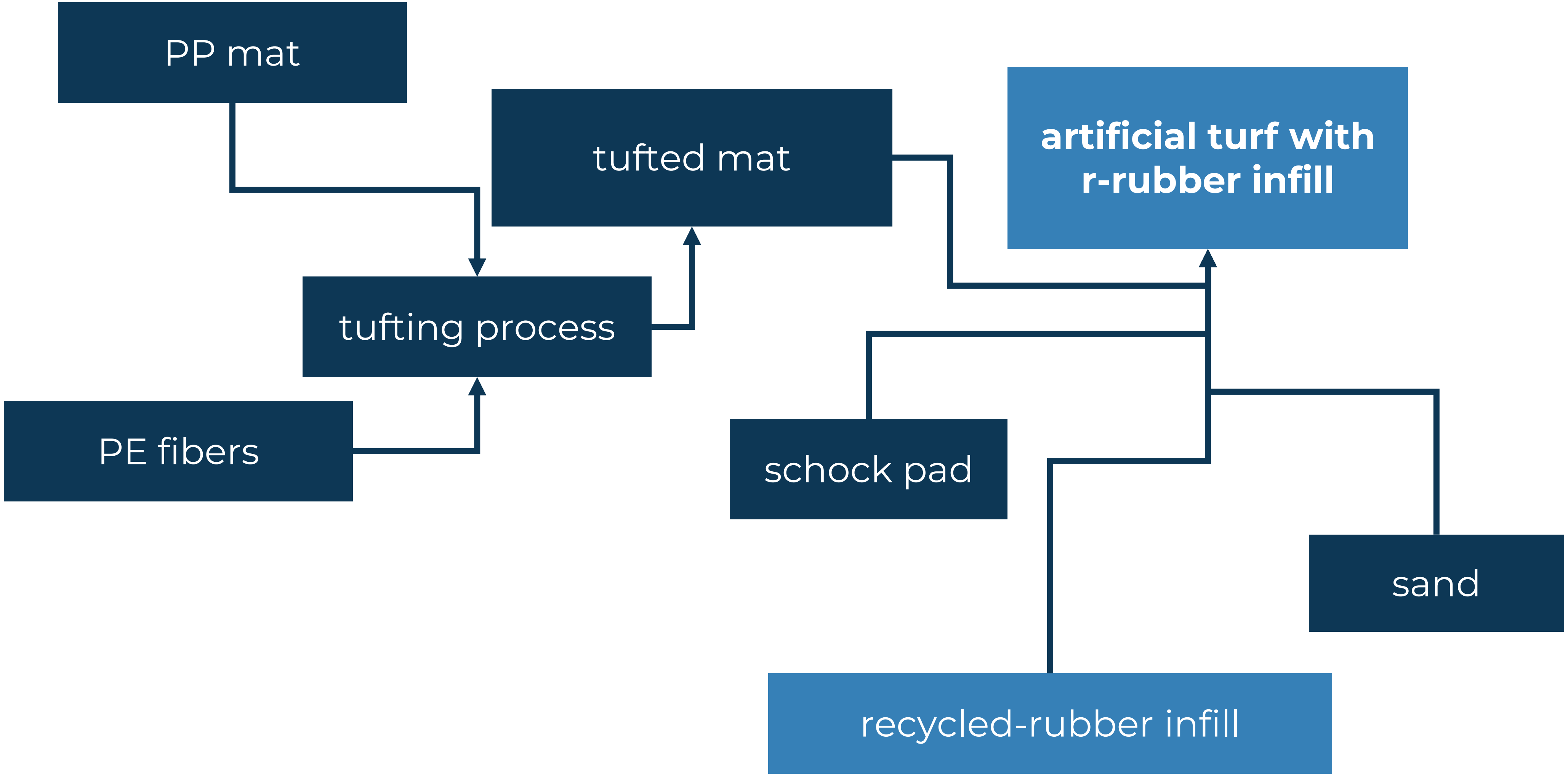
Alternative systems



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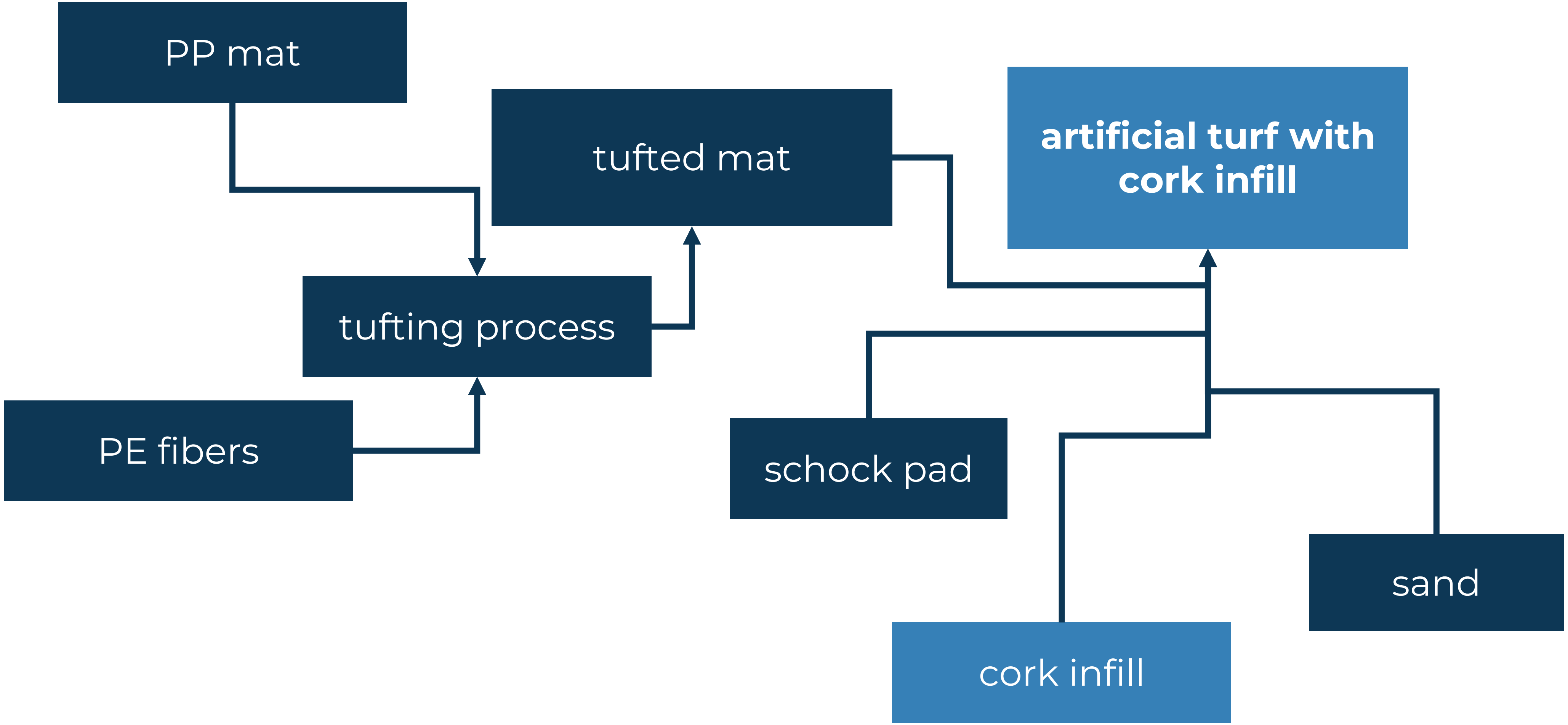
Alternative systems



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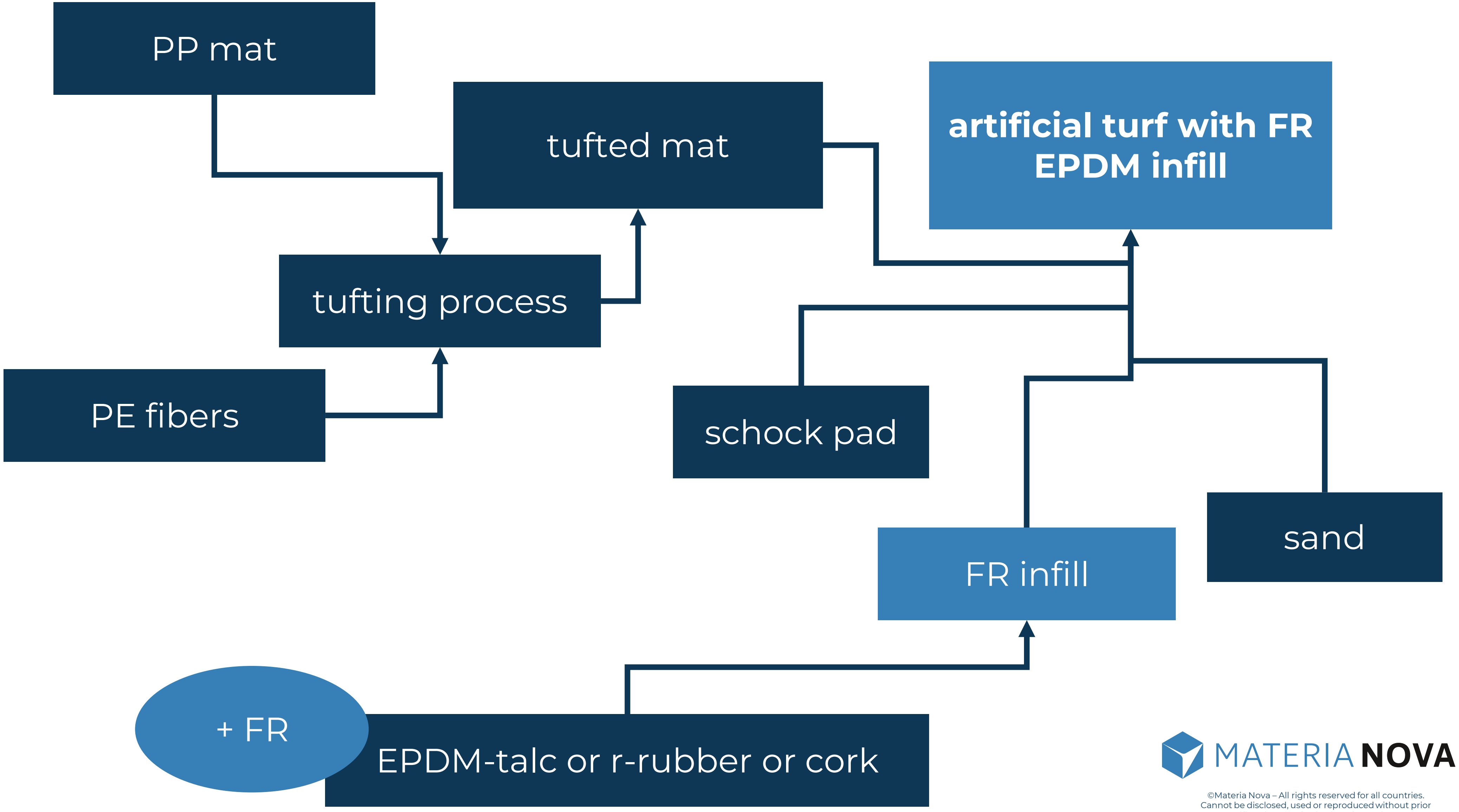
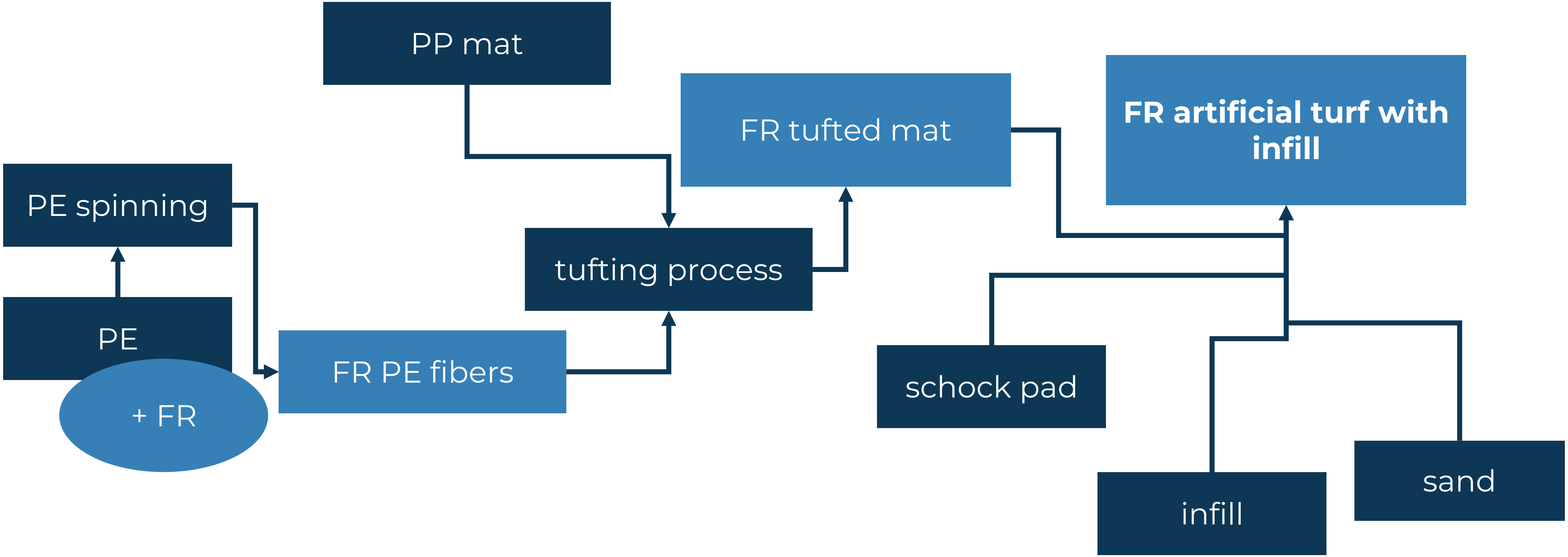
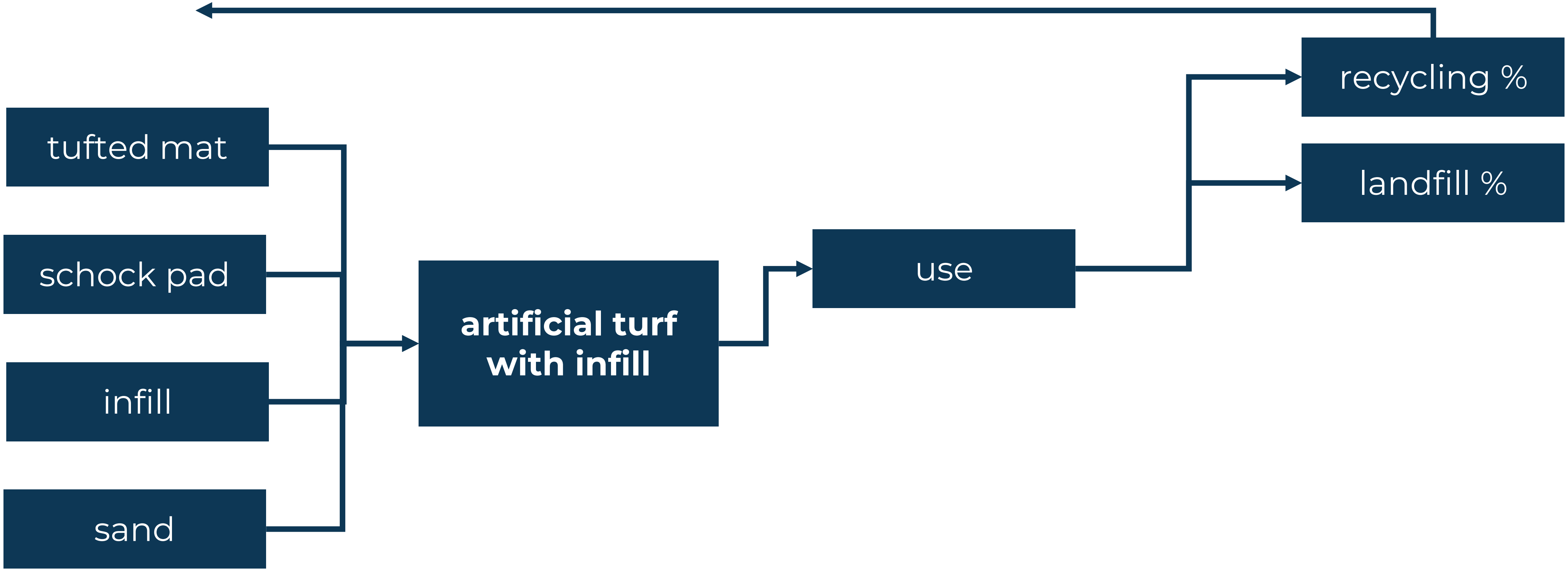
Alternative systems



Alternative systems



Full life cycle (for intended lifetime)



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Full life cycle (for intended lifetime)

cial turf
infill

use

recycling %

landfill %

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Accounting for fire accidents in LCA

LCA is based on (very) simple mathematics

$$EI(A+B) = EI(A) + EI(B)$$

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LC step 1

emission of 1 kg X

→ $IC_1(X) = x_1$

→ $IC_2(X) = x_2$

→ $IC_3(X) = 0$

LC step 2

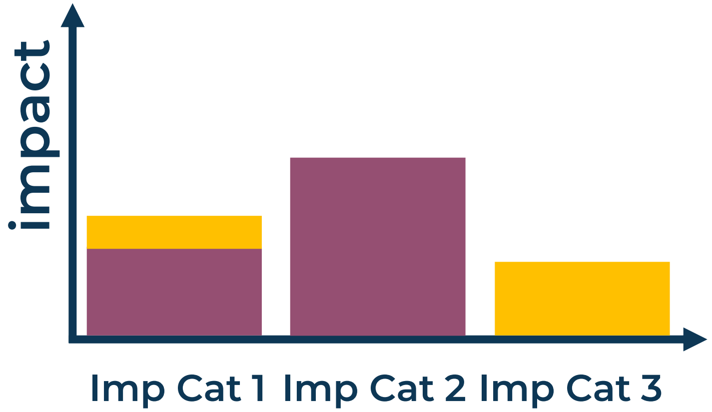
emission of 1 kg Y

→ $IC_1(Y) = y_1$

→ $IC_2(Y) = 0$

→ $IC_3(Y) = y_3$

Overall Life Cycle Impacts



Any system

$$EI(system) = EI(production) + EI(use) + EI(end\ of\ life)$$

Non-fire retarded system

$$EI(\overline{FR}) = EI(prod_{\overline{FR}}) + EI(use_{\overline{FR}}) + EI(eol_{\overline{FR}})$$

Fire retarded system

$$EI(FR) = EI(prod_{FR}) + EI(use_{FR}) + EI(eol_{FR})$$

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FR vs. $\overline{\text{FR}}$
What do we compare?

In LCA, everything is related to the function of the system

What is the common function of FR and $\overline{\text{FR}}$?

Not to burn? No.
To be used.

FR vs. $\overline{FR}$

Therefore, if $FR = \overline{FR} + fr$

$$EI(FR) = EI(\overline{FR}) + EI(fr)$$

$$EI(FR) > EI\ (\overline{FR})$$

because, obviously, $EI(prod_{fr}) + EI(use_{fr}) + EI(eol_{fr}) > 0$

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But…

Such systems should not be considered by LCA as if they would never burn. Because they may burn. Each of them.

How can we do that?

By including fire statistics and environmental consequences of fire events in the comparative LCA study

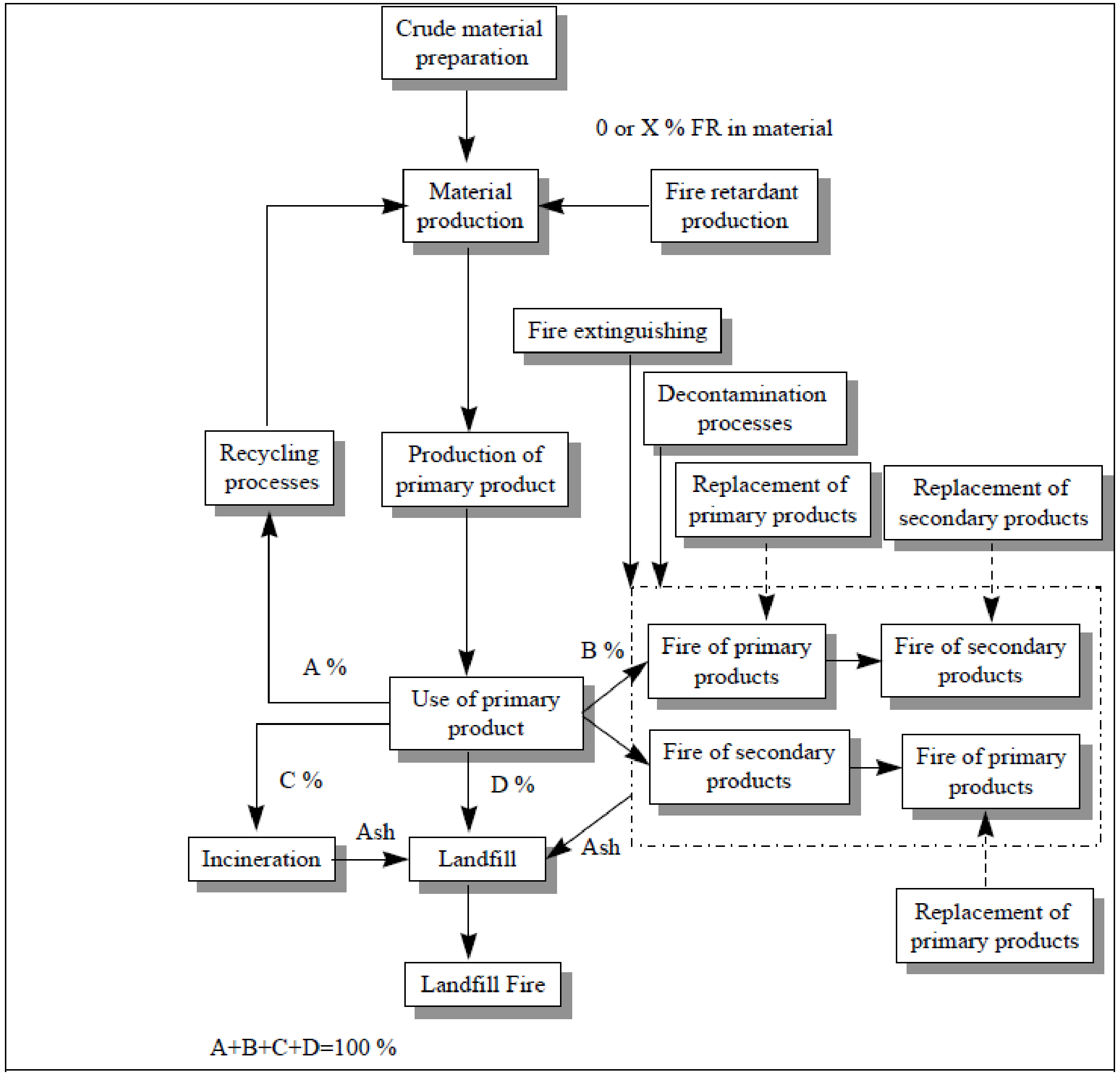

Figure 1: Schematic representation of the Fire-LCA model.

Source: Simonson, 2000

What if $\overline{\text{FR}}$ burns?

Consequences of the fire event

System has to be replaced, even partly
People may have to be healed
Room may have to be cleaned
Walls may have to be painted
Building may have to be rebuilt
Burnt system has to be discarded / treated
CO_2, particles, dioxins etc. are emitted
…

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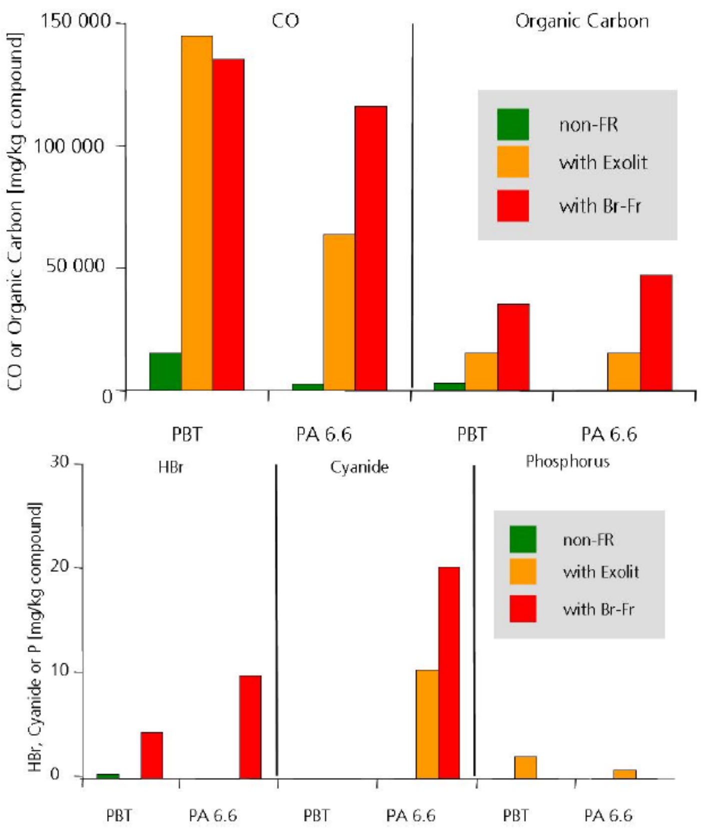
What if FR burns?

Consequences of the fire event

Similar consequences.
Maybe even worse consequences in terms of emissions.

Figure 5: Combustion products with acute toxicity as measured with the DIN oven.



Marzi, 2006
Toxic combustion products
green: $\overline{\text{FR}}$; orange & red: FR

Impacts of the two systems

$\overline{\text{FR}}$	FR
p(fire)*EI(consequences) + (1-p(fire))*normal EI($\overline{\text{FR}}$)	p'(fire)*EI'(consequences) + (1-p'(fire))*normal EI(FR)

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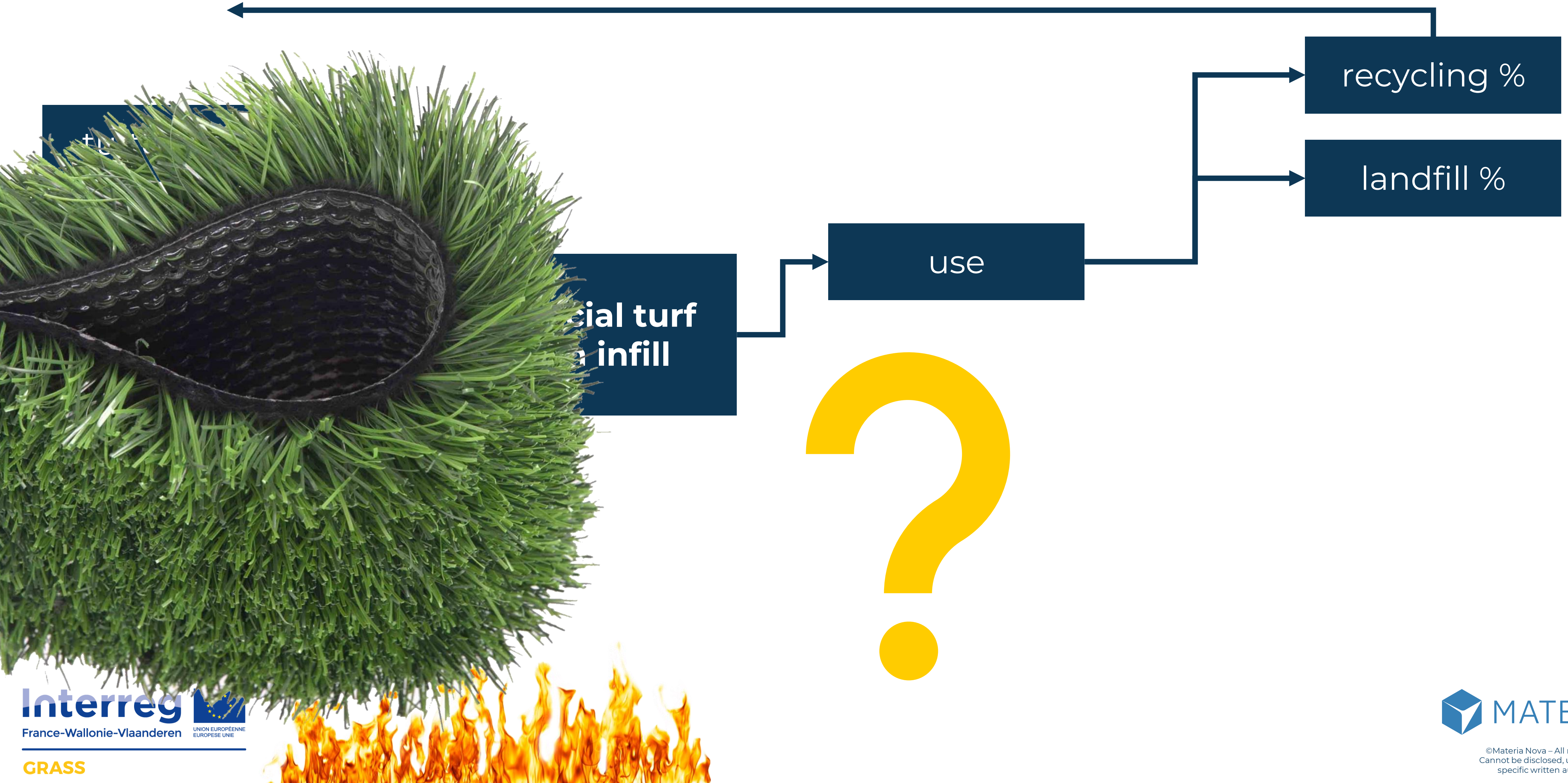
Full life cycle (for intended lifetime)



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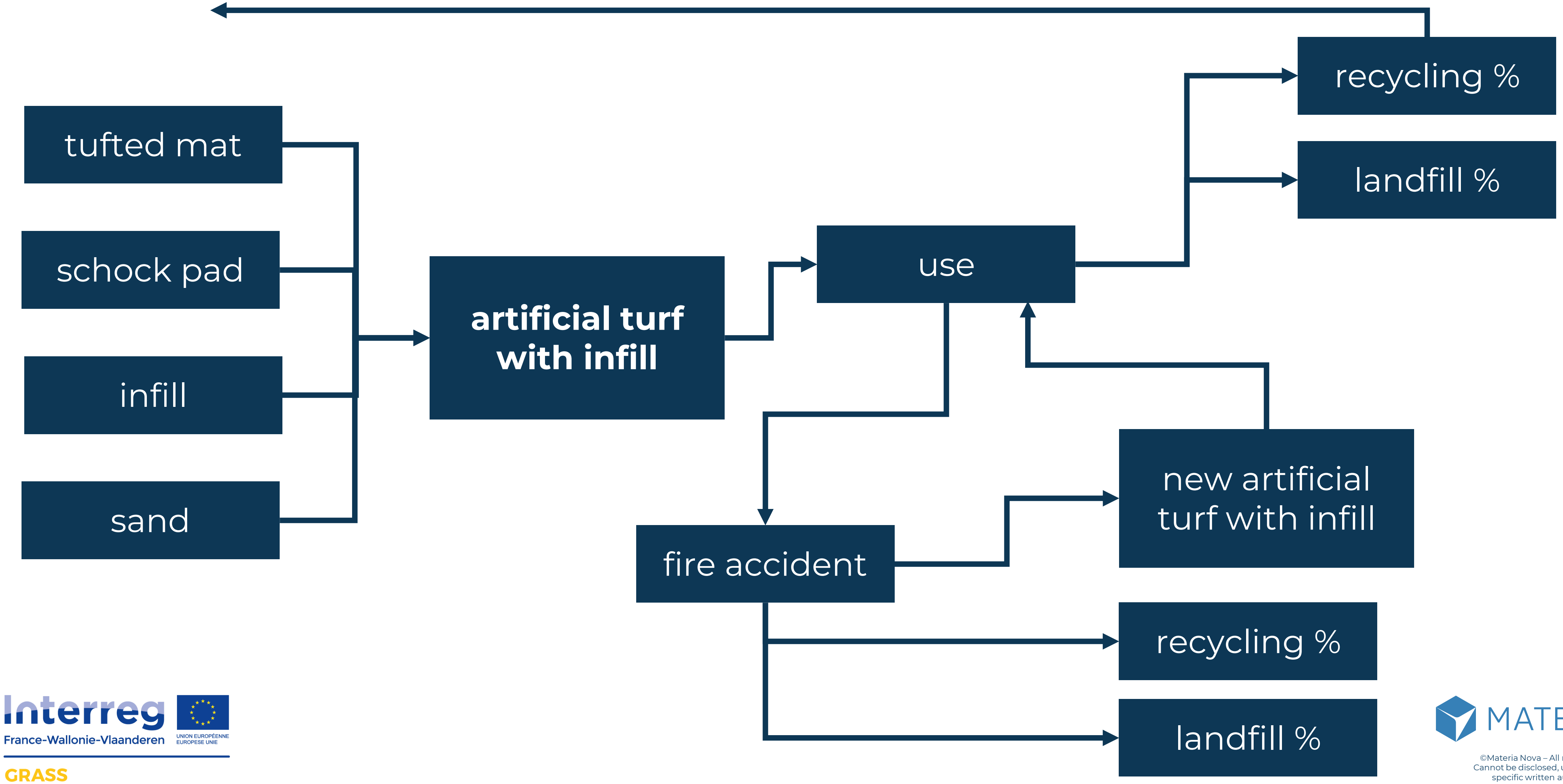

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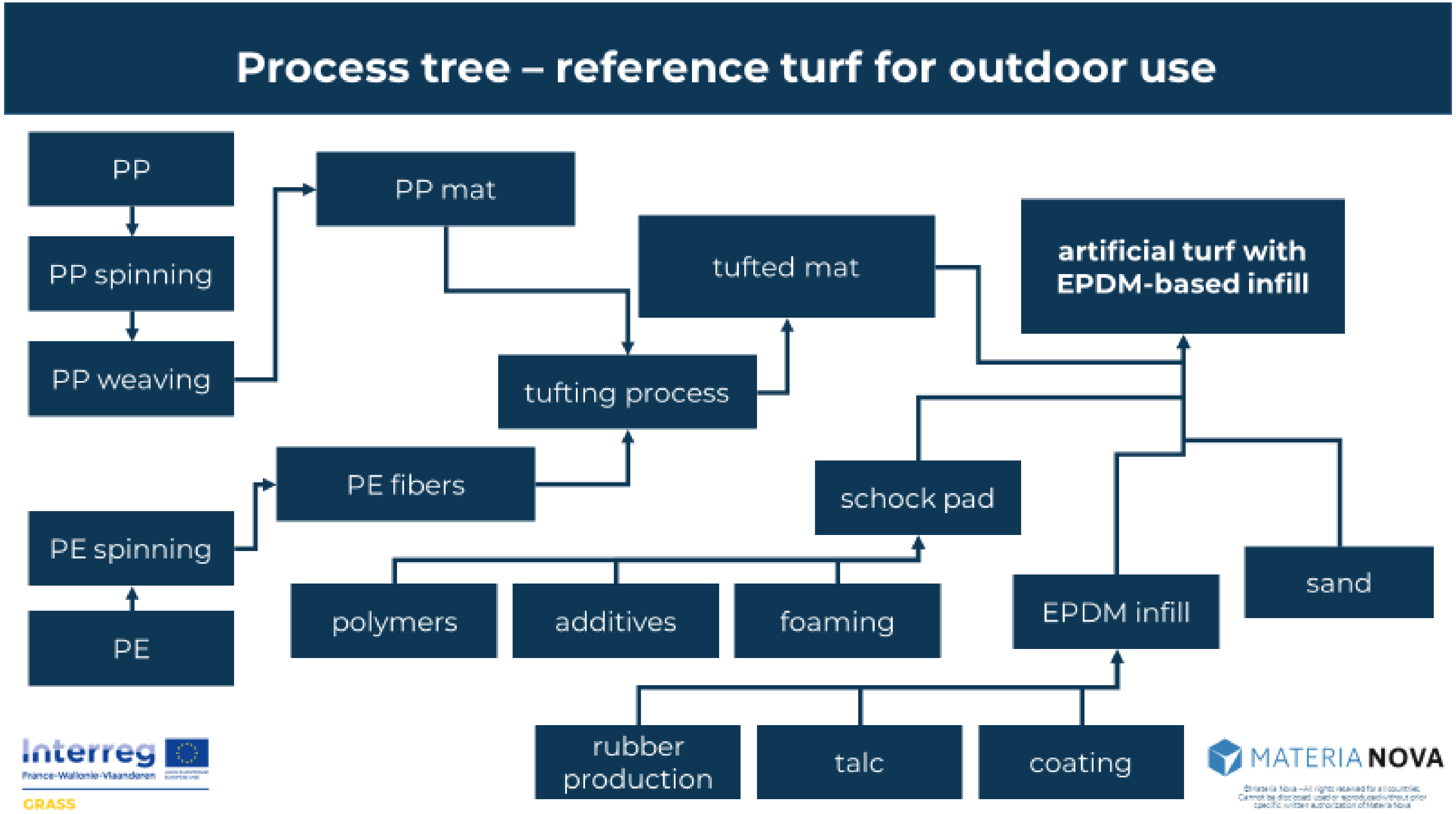
Data were therefore to be found about:

- impacts of fr production
- impacts of FR system production
- impacts of “normal” use phase
- impacts of disposal / treatment after “normal” use
- probability of fire events
- emissions directly linked to fr in case of fire
- other fire consequences
- impacts of disposal / treatment of burnt system

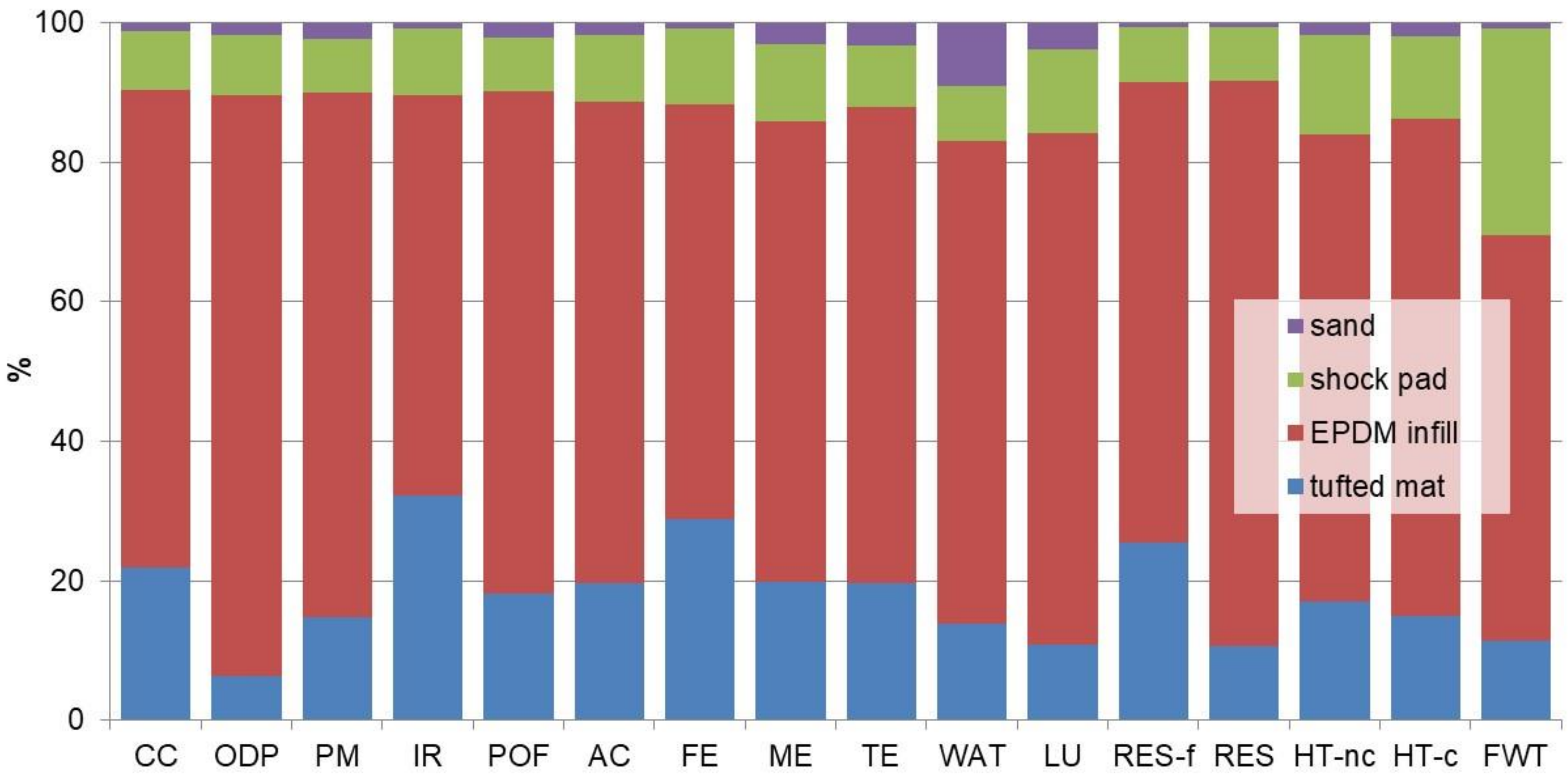
…

Results

Contribution analysis / reference system



Contribution analysis / reference system



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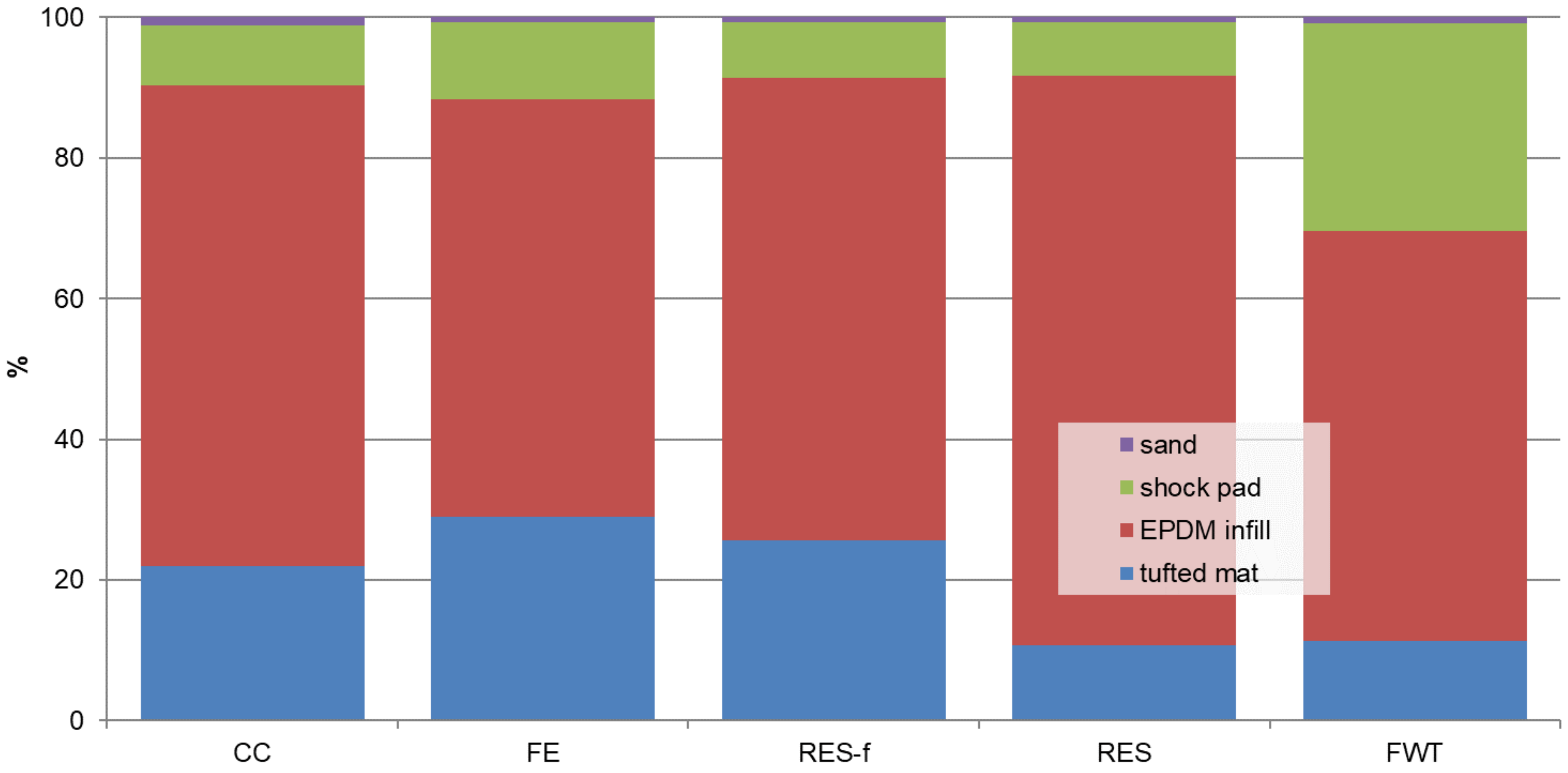
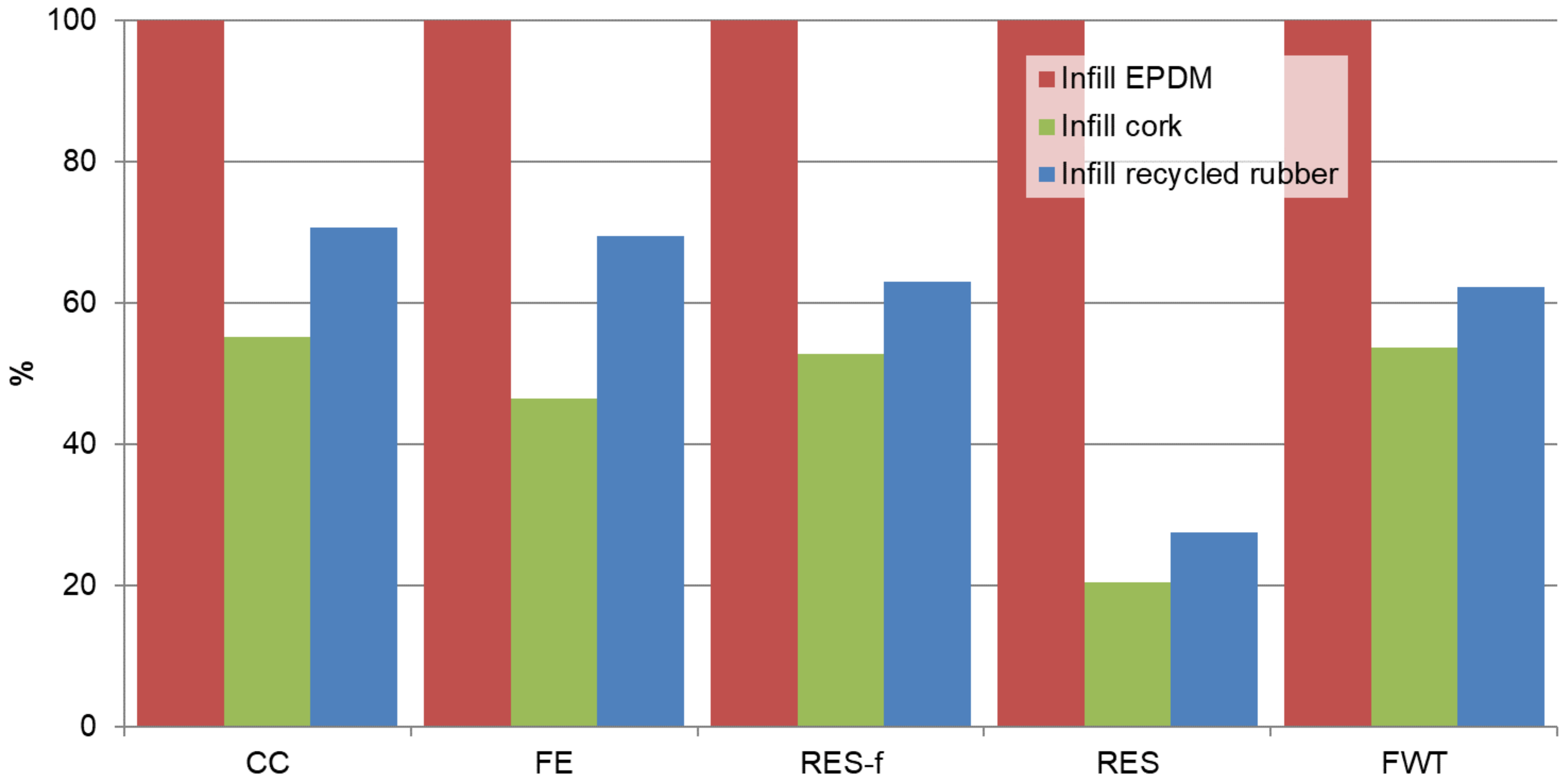
Contribution analysis / reference system / selected imapcts



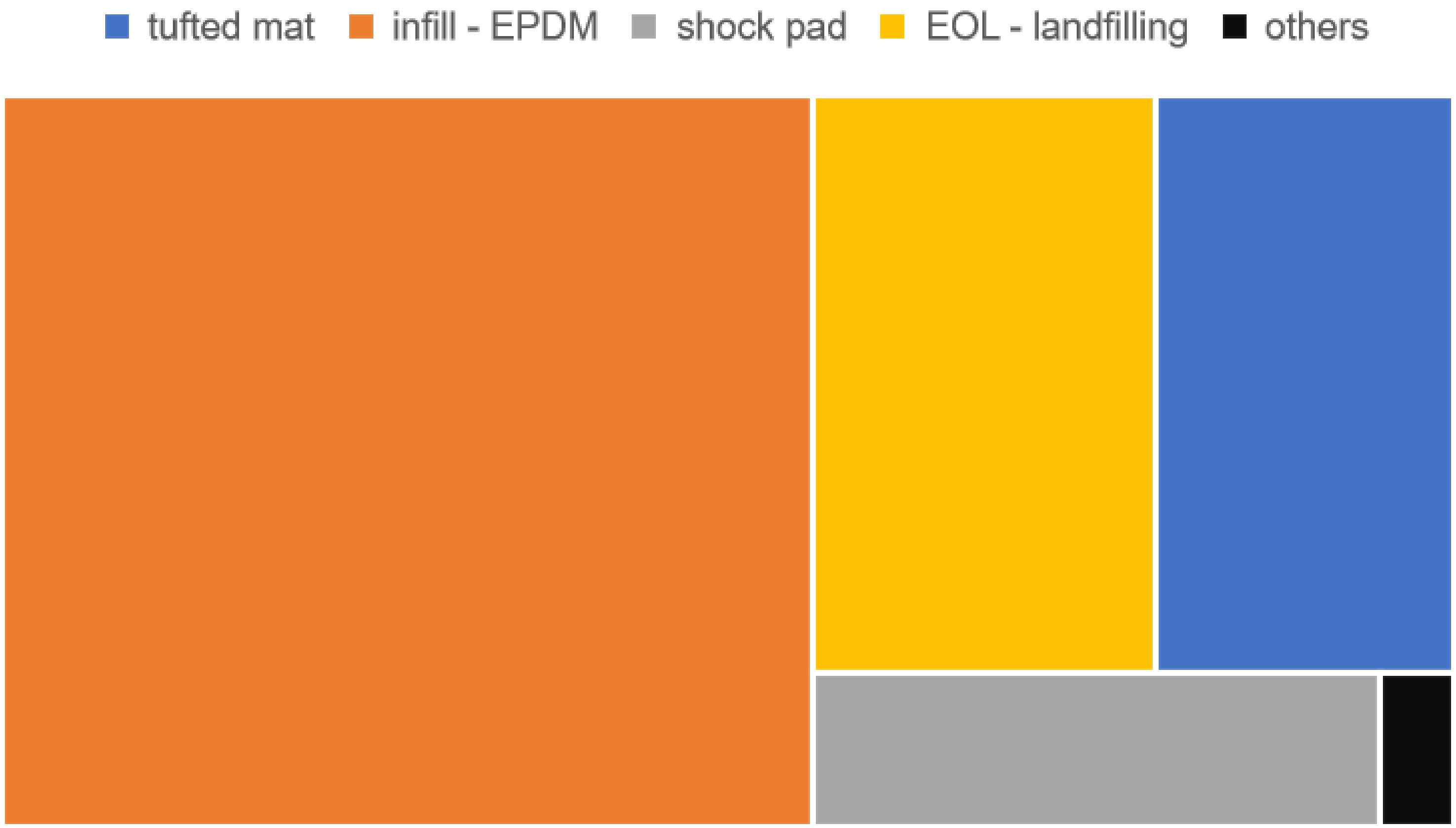
High contribution of infill to the environmental impacts

Compared impacts / alternative infills



Lower impacts for cork infill

Full Life Cycle – reference system (no FR, EPDM infill)



Contributions to the single score impact of the life cycle of non-FR artificial turf with EPDM infill

End of life scenarios

landfill	85,68%
recycling	14,29%
fire	0,03%

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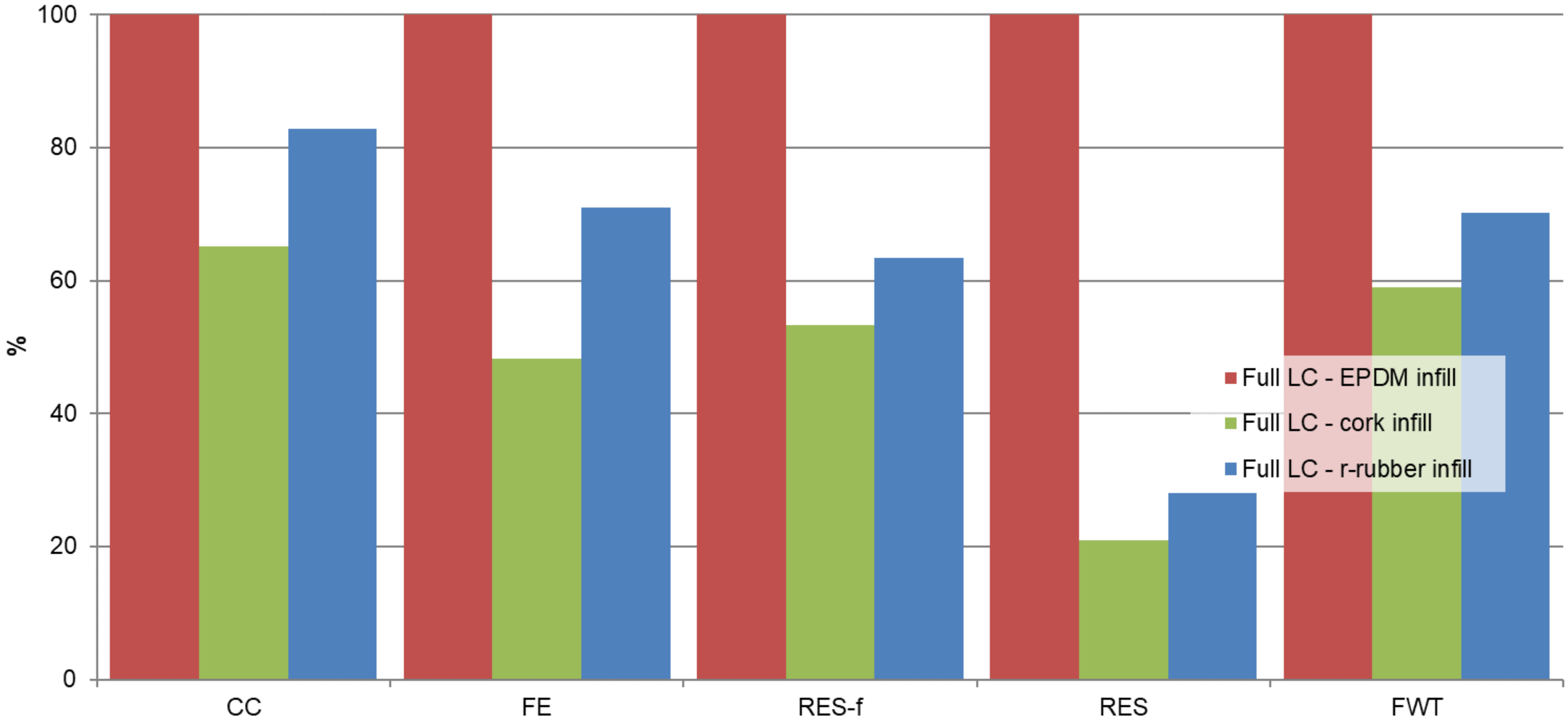
Full Life Cycle – alternative infills



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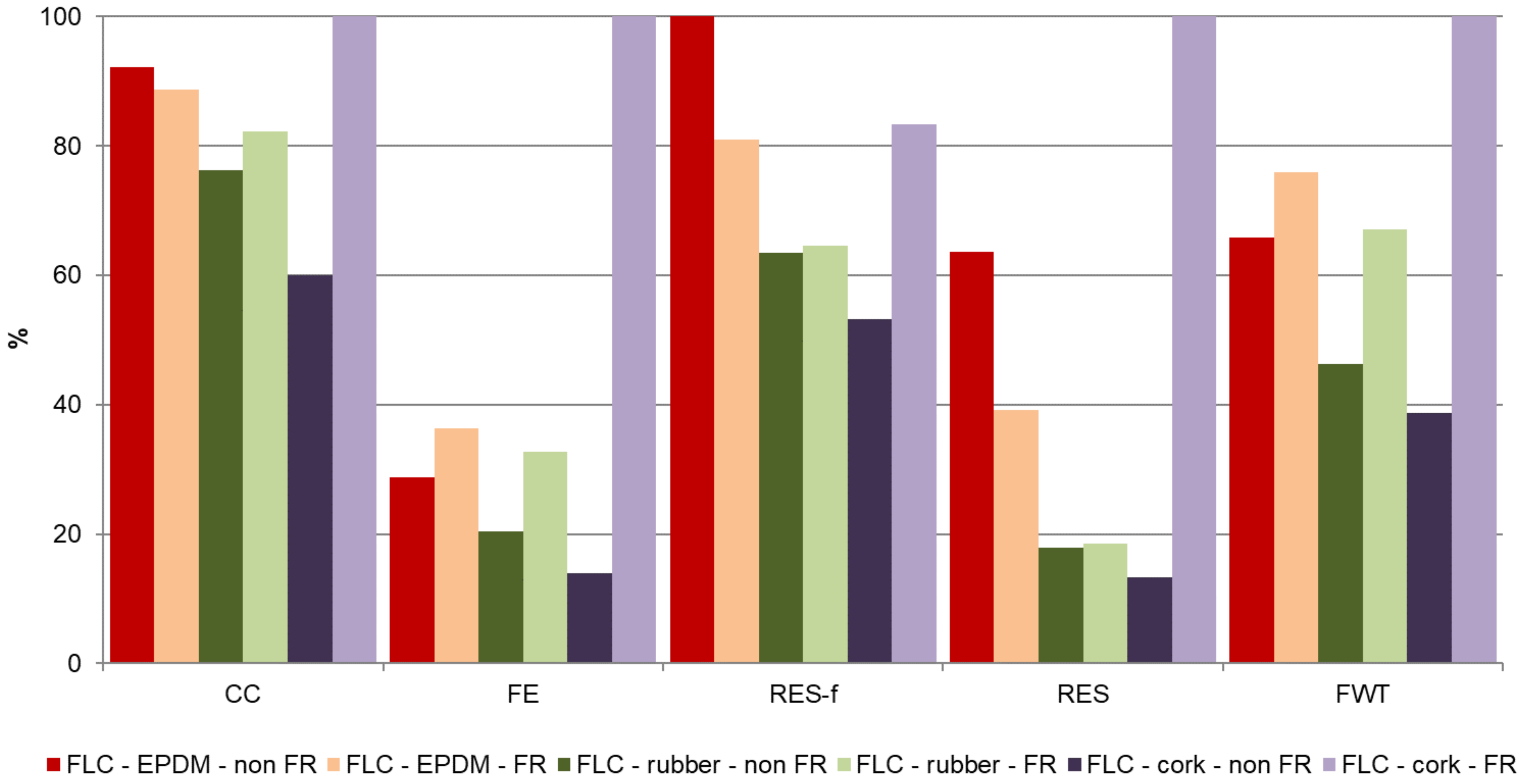
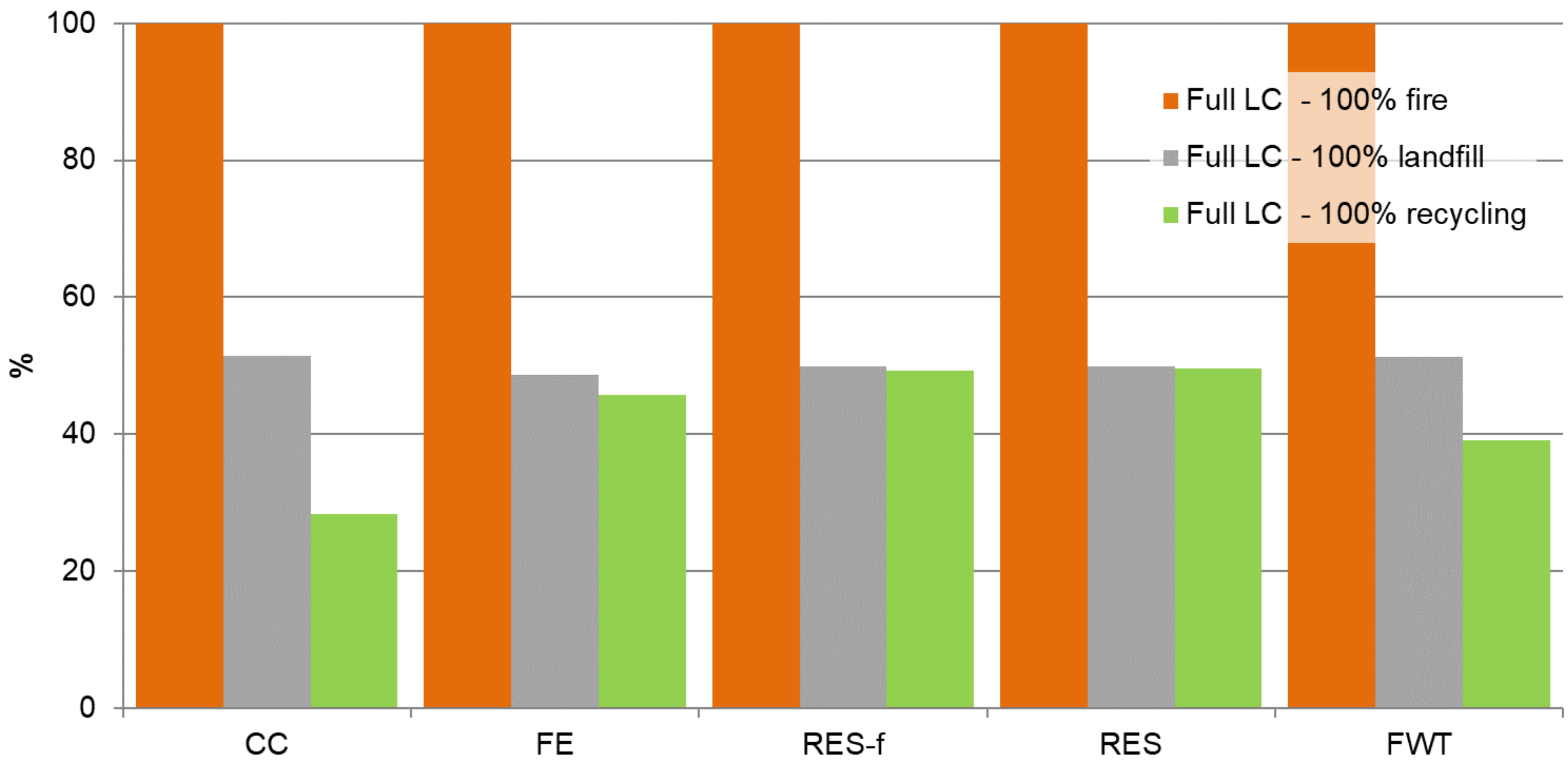
Full Life Cycle – effect of FR



Some impacts higher for FR systems!

Full Life Cycle – comparison of EOL scenarios



Full life cycle, reference system with EPDM infill – non FR

Yet, fire is as expected the most impacting end-of-life…

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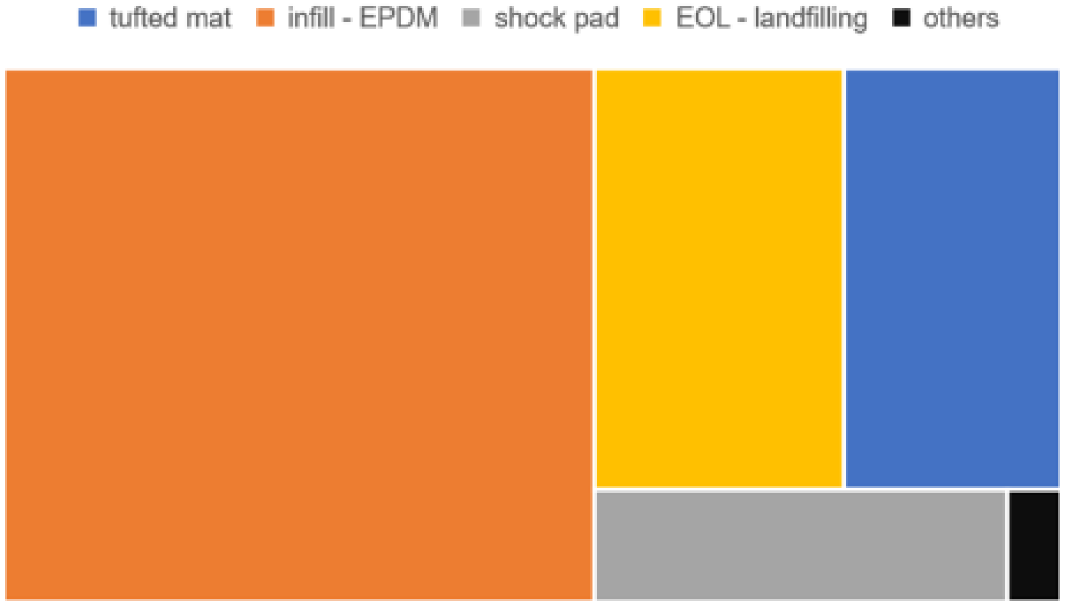
Full Life Cycle – contribution of EOL

Full Life Cycle – reference system (no FR, EPDM infill)



Contributions to the single score impact of the life cycle of non-FR artificial turf with EPDM infill

End of life scenarios

landfill	85,68%
recycling	14,29%
fire	0,03%

… but even without FR, the probability of fire is very low.

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Conclusions

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- infill is identified as the main contributor to artificial turf impacts

- turf with cork infill may be less impacting than with synthetic infills

- adding flame retardancy properties may induce higher impacts

- however, this LCA does not account for potential life saving by preventing heavy fire events… and non-FR system will not pass safety requirements

- eco-designing fireproofing solutions may lead to significant impact reductions

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