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## User-friendly tool based on simplified parametrized Life Cycle Assessment models to optimize returnable packaging

Samuel Le Féon, Geneviève Gésan-Guiziou, Gwenola Yannou-Le Bris, Joël Aubin, Julien Hilaire, Caroline Malnoe, Caroline Pénicaud

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# User-friendly tool based on simplified parametrized Life Cycle Assessment models to optimize returnable packaging

Samuel Le Féon\*, Geneviève Gésan-Guiziou, Gwenola Yannou-Le Bris, Joël Aubin, Julien Hilaire, Caroline Malnoë, Caroline Pénicaud

EFFoST Conference 2024 – Bruges, Belgium



OK TO SHARE  
ON SOCIAL MEDIA



# The project and the French case study

## FAIRCHAIN H2020 project

Innovative technological, organisational and social solutions for FAIRer dairy and fruit and vegetables value CHAINS

From November 2020 to December 2024

25 partners, 8 countries

6 case studies

**Final event at EFFoST is tomorrow!**

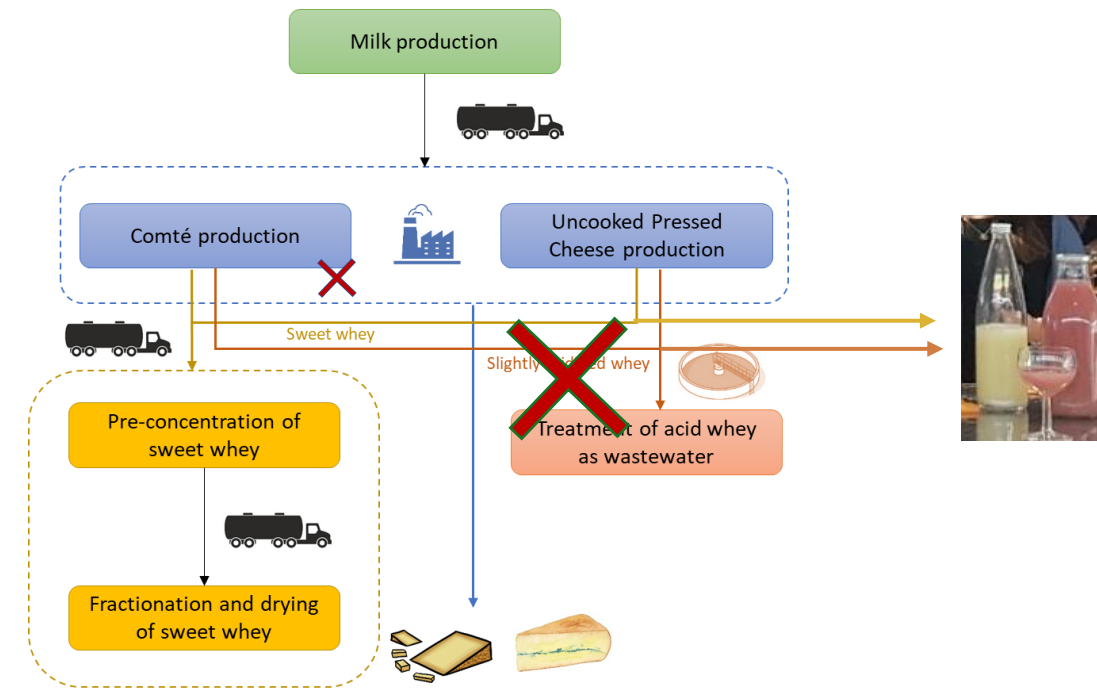
8.30 – 10.00: plenary session  
13.30 – 16.00: networking forum



## French Case Study – innovative fermented whey-based drink

Current value chain: part of the whey is sent to wastewater treatment

Future value chain: whey is used to produce a fermented drink that is distributed in reusable bottles



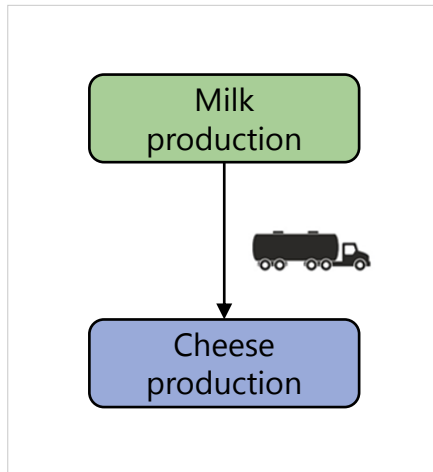
<https://www.journalvignette.fr/consigne-bouteilles-verre-grand-retour/>

**Focus of my presentation**  
More specifically the related environmental impacts and benefits

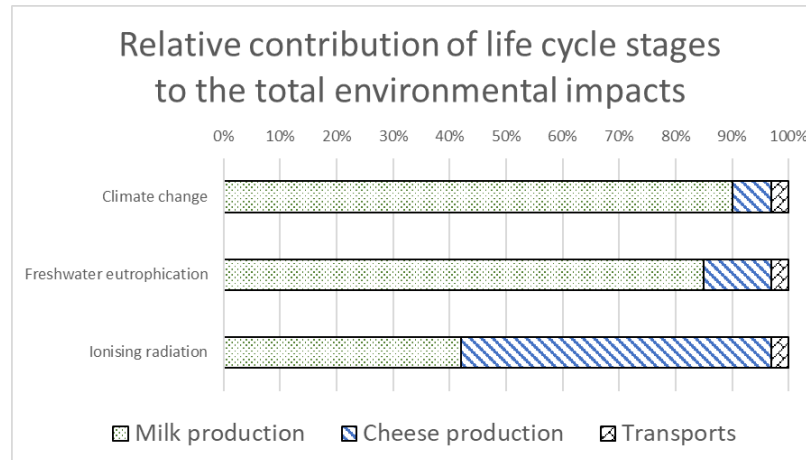
# A few words about Life Cycle Assessment

Life Cycle Assessment (LCA): a method to quantify the environmental impacts

« multi-step » (life cycle)



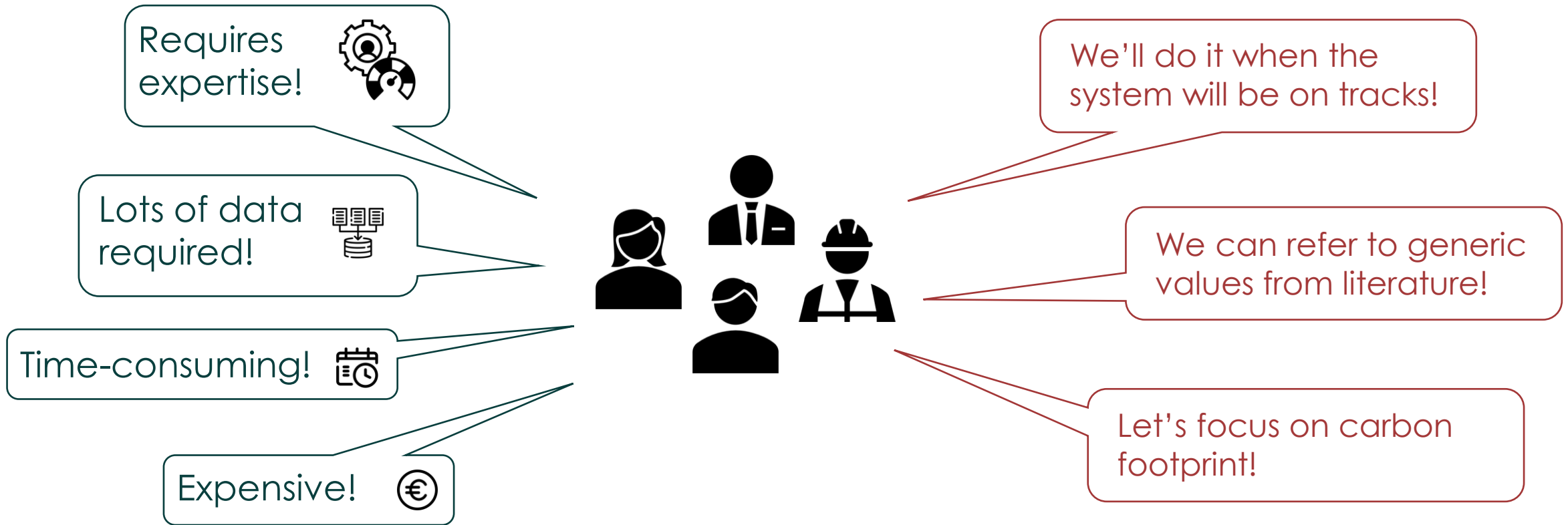
« multi-indicators »



Various applications

- Identify the environmental hotspots of a system (ecodesign)
- Quantify the total impacts of systems (comparisons, ecolabelling)

# Feedback from stakeholders





# Using LCA for reusable bottles (e.g., France)

A look at companies' websites

**J'AI MES BOUTEILLES**  
CONSIGNE pour RÉEMPLOI  
33% d'économie d'eau  
79% d'économie de CO<sub>2</sub>

**MES BOUTEILLES JE LES RAMÈNE !**  
LE SERVICE CLIENT Choisir l'emballage consigne, c'est choisir un emballage durable.  
L'impact du réemploi versus le recyclage.

**RÉDUIRE SON IMPACT ENVIRONNEMENTAL**  
DISTRIO  
Une bouteille réemployée plutôt que recyclée c'est \*\* :  
• 79% de gaz à effet de serre produit en moins  
• 76% d'énergie primaire en moins  
• 33% d'eau économisée !  
\*\*\_d'après ce document, eau.Deroghe.Consultants, en 2009.

En le réemployant, on économise jusqu'à 75 % d'énergie, 79 % d'émissions de gaz à effet de serre et 33 % d'eau par rapport au recyclage.

**biocoop**  
-76% d'énergie  
-79% de gaz à effet de serre  
-33% d'eau

**Haut la Consigne**  
-75% ÉNERGIE  
-33% EAU  
-79% GES\*

**Moins de CO<sub>2</sub>**  
Laver les emballages en verre à 80° permet d'épargner 79% de CO<sub>2</sub> par rapport à la bulle à verre (fondre à 1500°) sur le cycle de vie complet.

**Moins d'eau**  
Contrairement à ce qu'on pourrait croire, le lavage consomme 30% d'eau en moins par rapport au recyclage du verre puisque ce dernier consomme beaucoup d'eau pour la préparation des matières premières (eau, quartz, ...).

**Reboteille**  
Suivons la consigne !  
Bénéfices écologiques du réemploi  
Source : cabinet Senoche Consultant  
-51% d'eau  
-76% d'énergie  
-79% de GES

**Bout à Bout**  
Avantages du réemploi par rapport au recyclage  
-79% d'ÉNERGIE  
-77% d'ÉMISSIONS DE CO<sub>2</sub>  
-51% d'EAU  
Dispositif de réemploi ou réutilisation des emballages ménagers en verre en France. AGENE 2018

Same environmental performances for every companies (from a national French study)

Carbon footprint  
Water use  
Energy use



# Using LCA for reusable bottles (e.g., France)

A look into the national study

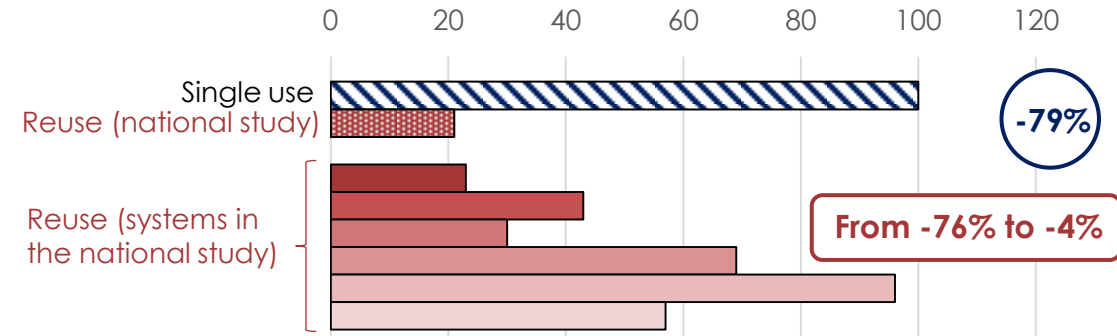


Dispositif		19,27	3,98	6,11	1,93	1,14	4,75
Catégorie d'impact	Changement climatique	-77 %	-57 %	-70 %	-31 %	-4 %	-43 %
	Acidification	-85 %	-61 %	-75 %	-36 %	-13 %	-61 %
	Eutrophisation aquatique des eaux douces	-65 %	-23 %	-49 %	-3 %	-11 %	-29 %
	Eutrophisation aquatique marine	-82 %	-52 %	-69 %	-30 %	-11 %	-59 %
	Déplétion des ressources minérales et fossiles	-73 %	-50 %	-62 %	-26 %	-13 %	-64 %
	Déplétion des ressources en eau	-51 %	+6 %	-60 %	-9 %	-21 %	-41 %
	Consommation d'énergie primaire non renouvelable	-79 %	-56 %	-73 %	-26 %	-6 %	-53 %
	Emission de particules	-83 %	-60 %	-71 %	-30 %	-18 %	-61 %
	Bénéfice environnemental significatif du système avec consigne	65 % - 85 %	50 % - 61 %	49 % - 75 %	26 % - 36 %	Non significatif	43% -64 %

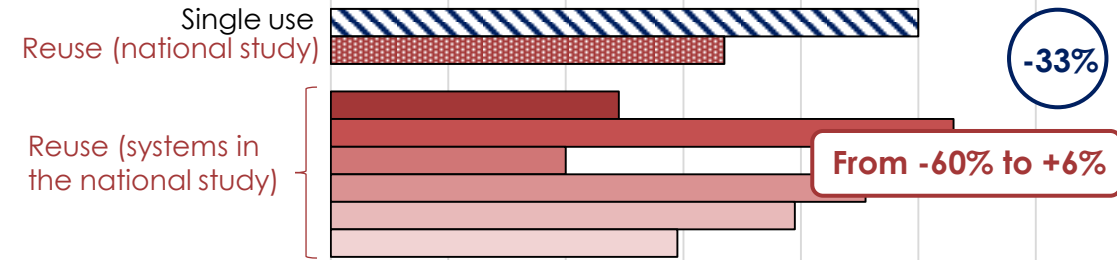
Variability between the studied systems:

- Operational parameters (e.g., individual or shared bottle stocks)
- Technical parameters (e.g., return rate)

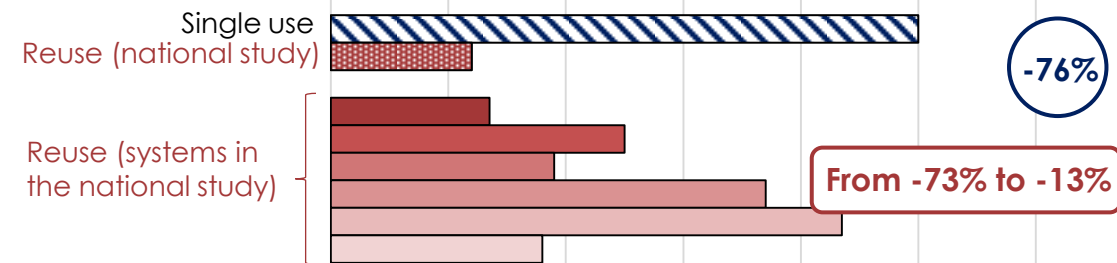
Carbon footprint



Water use

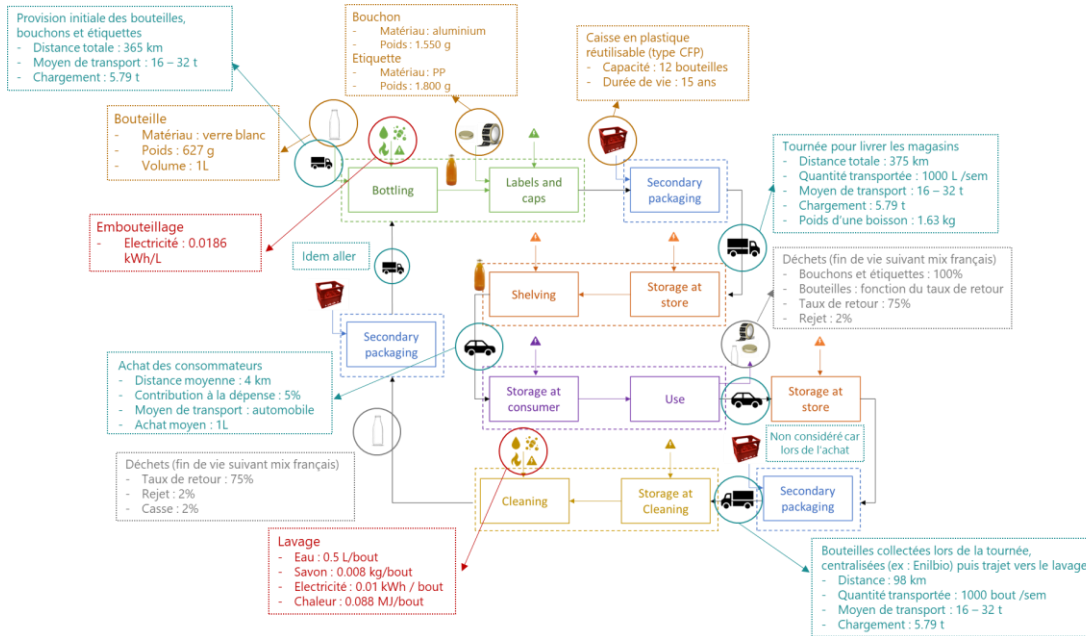


Energy use



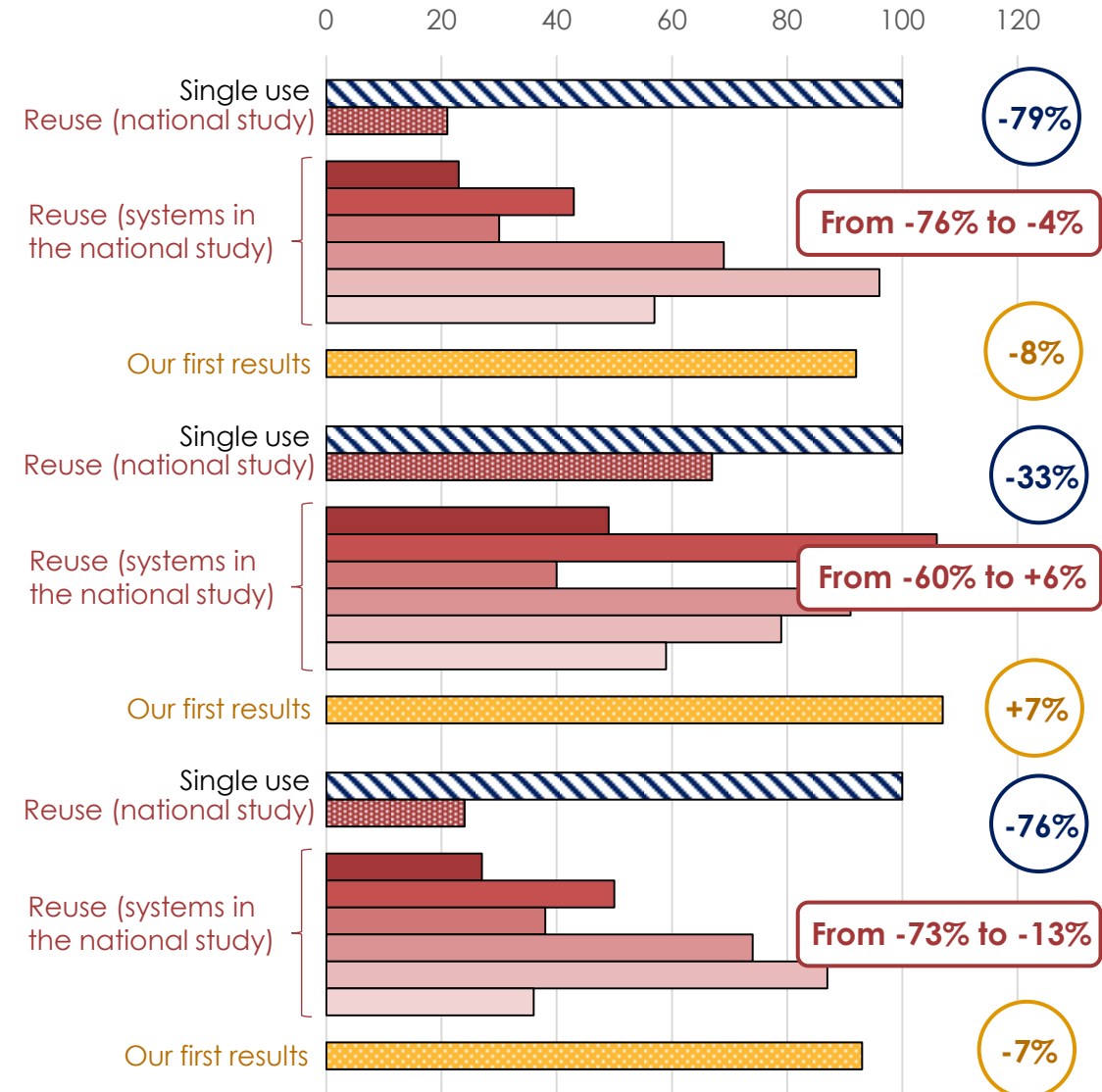
# Using LCA for reusable bottles (e.g., France)

What about our – first – results in FAIRCHAIN?



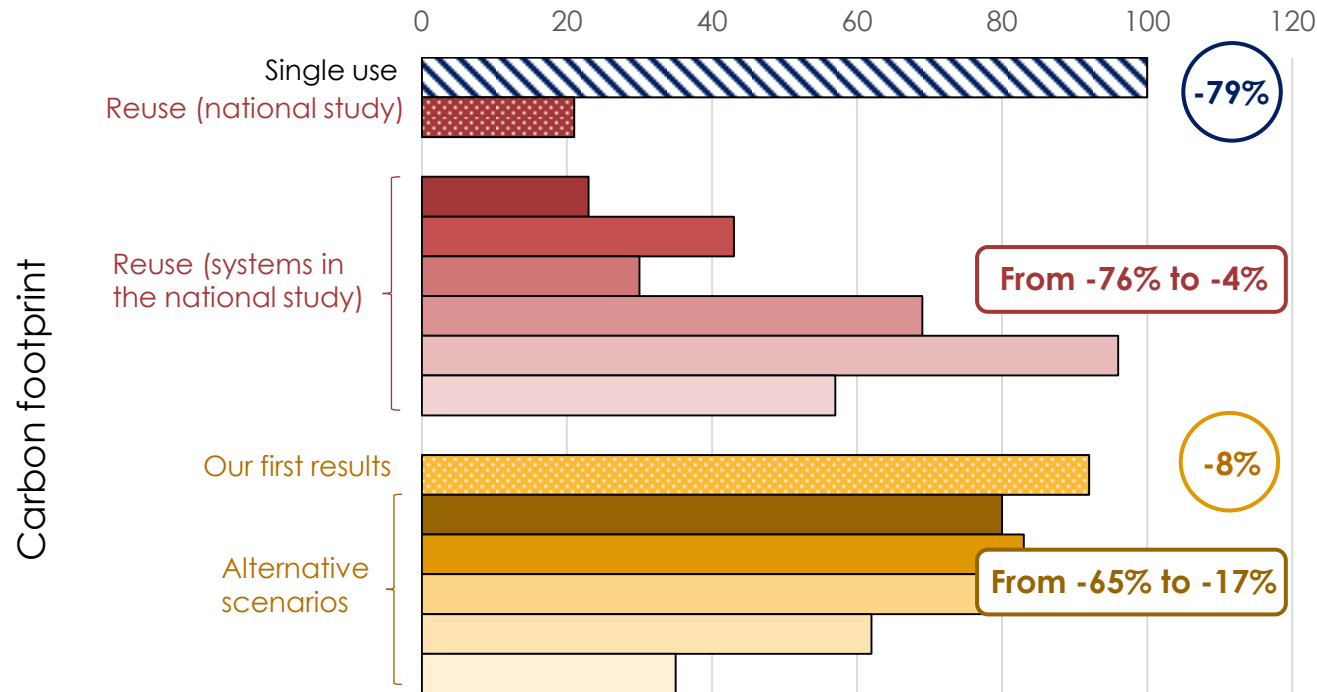
Not as good...

Carbon footprint  
Water use  
Energy use





# Can we do better in FAIRCHAIN?



Yes it seems we can!

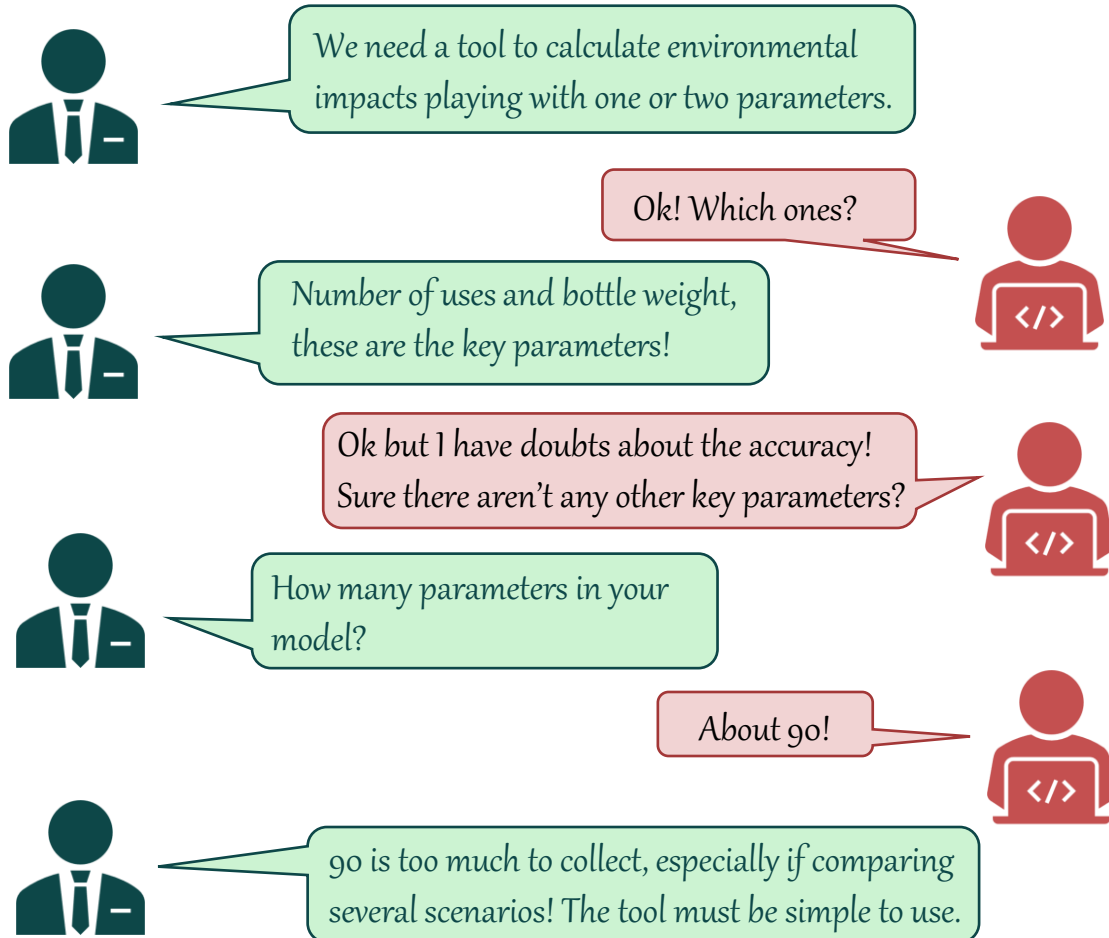
But how to allow the stakeholders to test their own scenarios, in autonomy, with low LCA expertise?

Alternative scenarios based on organisational (e.g., logistics) and/or technical (e.g., lighter bottles) improvements

Le Féon et al. (2024), Life Cycle Assessment based optimization of scenarios of reusable glass bottles using context-specific key parameters, Cleaner Environmental Systems



# Chatting with stakeholders



## The challenge

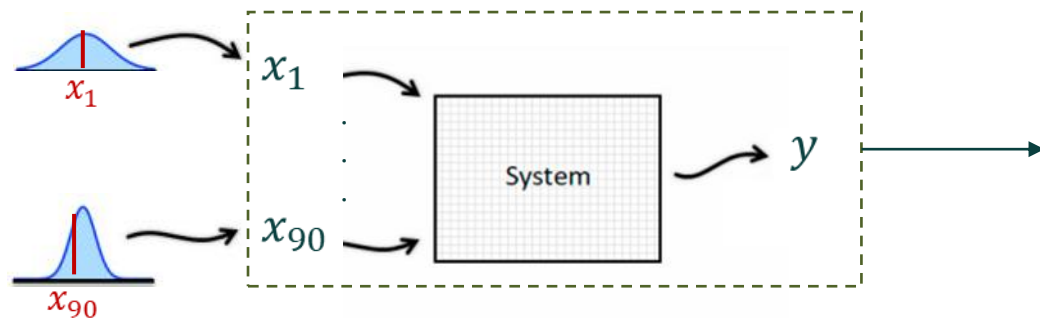
Develop a tool to help stakeholders to test various scenarios and make early decisions (ecodesign)

Make the tool simple, especially by limiting the number of required data

Preserve the scientific accuracy.

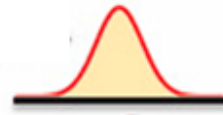
# A tool based on simplified parametrized LCA models

$$\text{Impact}_{\text{climate change}} = y = f(x_1, \dots, x_{90})$$



## Generalized Variance Decomposition

Monte Carlo simulations



Sobol indices

$$S_i = \frac{\text{Var}[E(Y|X_i)]}{\text{Var}(Y)}$$

Variance of Y means, knowing  $X_i$

Variance of Y means

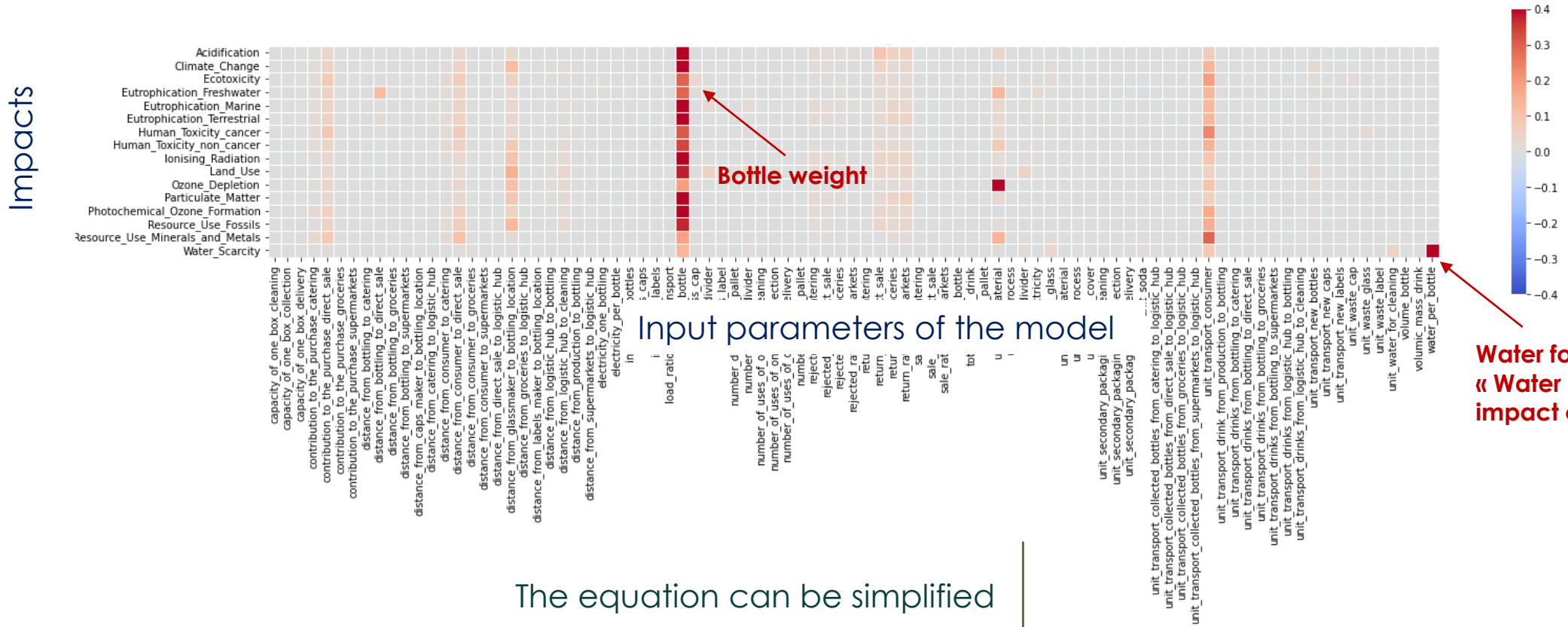
The higher the Sobol index, the more the output is sensitive to the corresponding input parameter

*If the value of a « small Sobol » input parameter is modified, it will not modify the results significantly*

(Padey, 2012; Douziech et al., 2021)

# The simplification

Matrix of Sobol indices



The equation can be simplified

$$Impact_{climate\ change} = y = f(x_1, \dots, x_{90}) \approx g(x_{12}, x_{22}, x_{34})$$

Input parameters kept if  $S_i > 0,05$  for at least one impact category  
 Other input parameters set to mean values



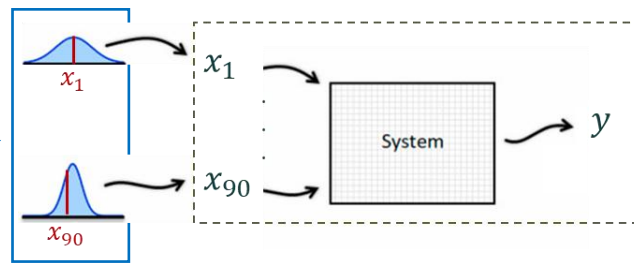
# Main limit at this point

To generate a simplified model, we need

The impact equation  
(LCA practitioner and  
sectorial expert)

$$\text{Impact}_{\text{climate change}} = y = f(x_1, \dots, x_{90})$$

Statistical distribution for  
input parameters (from  
literature and sectorial  
experts\*)



**Main limit: the simplified model is associated to a domain of applicability, dependent from:**

- 1. The impact equation** that may change depending on how the system is organized
- 2. The statistical distributions.** If we want to cover large, some input parameters could overshadow the others (e.g., distance to cleaning)

\* Hugues Pelletier, Charles Allart (**PETREL**), Muriel Charlet, Delphine Renevier, Mathieu Ganier (**J'aime Mes Bouteilles**), Antoine Clapier (**DISTRO**), Romain Legras, Loïc Marchand-Williamme (**La Station, La feuille d'érable**) et Arnaud Michel (**Le Hub Ethique**)



**We need simplified models for different types of systems**



# A typology of reusable bottle systems

Stock of bottles	Cleaning	Distance to cleaning	Production and bottling sites	Sale channels	Third-party for logistics	Bottle manufacturer	Market	Reverse vending machine	Collection	Bottle type <sup>1</sup>	Maturity of the system
Individual (to one producer)	Internalized	< 100 km	Same	Mix	Yes	In the area	Regional	No	Not Integrated	75 cl brown bottle (beers)	< 5 years
Mutualized (between producers)	Externalized	> 100 km	Different	Direct sale	No	In the Country	National	Yes	Integrated	75 cl white bottle (sparkling drinks, lemonade type)	5 to 10 years
				Catering		In Europe	International			75 cl green bottle (cider type)	> 10 years
				Supermarkets						1 l white bottle (juices)	
				Groceries							

Already 1 672 simplified models developed

Simplified LCA models are generated for each combination of modalities of the typology (called archetypes), using specific equation and statistical distributions

The global domain of applicability is large  
The accuracy is better at the archetype level



# SEAMPL (Simplified Environmental Assessment of Packaging Loops)

**SEAMPL**

Configuration of reuse bottle scenario to evaluate

Scenario name: \_\_\_\_\_

Single use

**Stock and Cleaning**

Stock of Bottles: select

Cleaning: select

Cleaning Distance: select

**Production and Bottling**

Bottle type: select

Production and bottling locations: select

Location of the glassmaker: select

**Logistics**

Third-party for Logistics: select

**Sales and Market**

Sales Channel: select

Market: regional

Maturity of the system: select

**Collection and Reverse Vending**

Collection: select

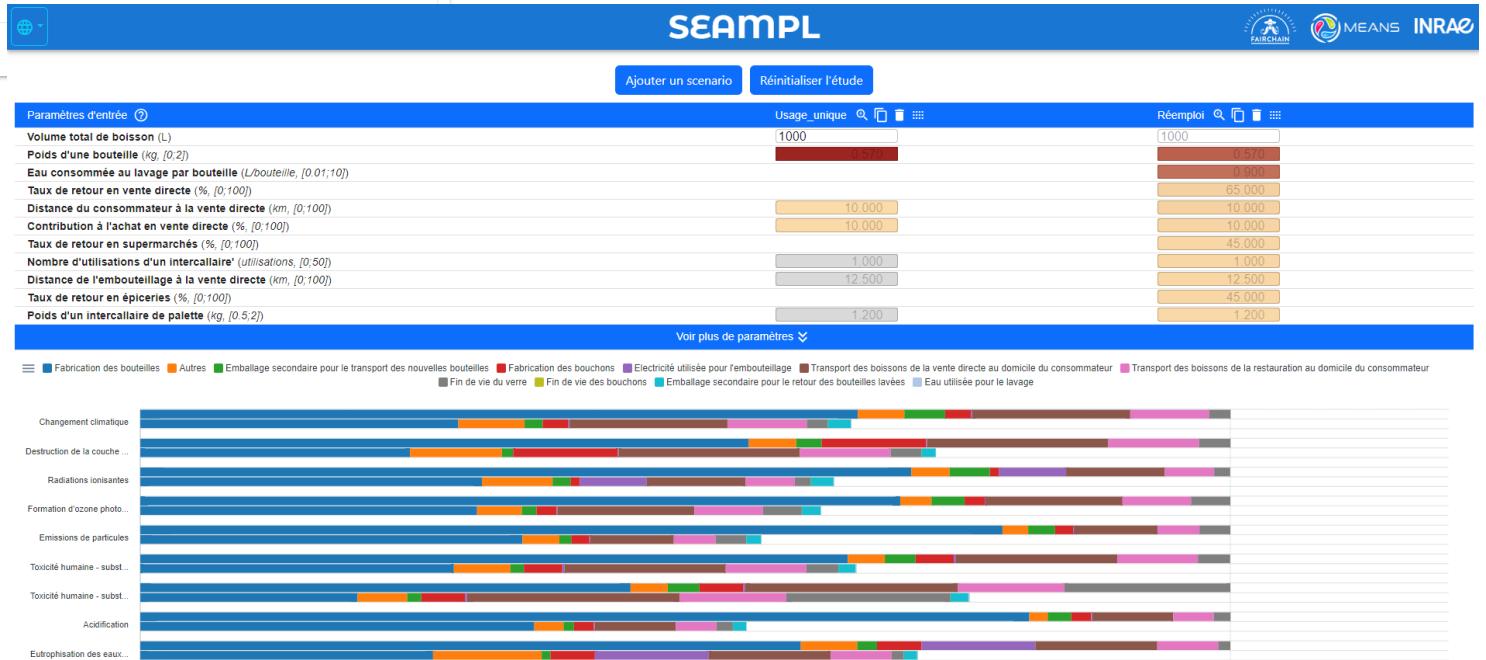
Reverse Vending Machine: no

Possibility to compare scenarios of different archetypes

Possibility to compare to single-use

Simple questions to define the archetype

Data provision and LCA results



\* <https://means.inrae.fr/>

Samuel Le Féon, EFFoST2024 conference, Bruges, Belgium

# Feedback from the actors

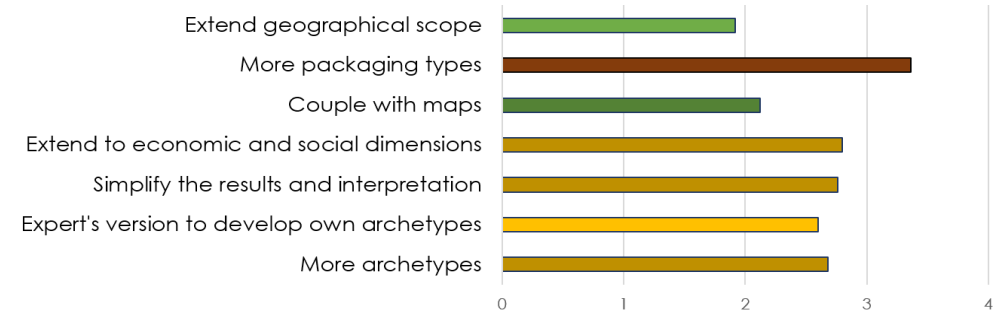
## Development:

- More packaging types
- Economic and social issues

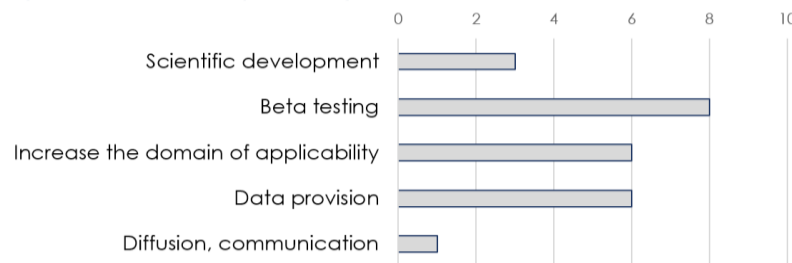
Free or low-price (SMEs)

Supported by public authorities

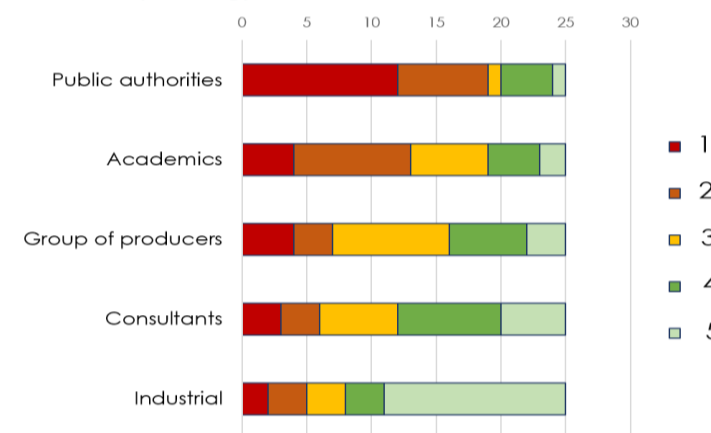
What should be the priority developments?  
(several answers possible)



How are you ready to help?  
(several answers possible)



Who should support the tool?  
(ranking)



Which type of license?  
(one answer)



## Co-authors and project partners

**Caroline Pénicaud et Gwenola Yannou-Le Bris** (AgroParisTech),  
**Joël Aubin, Caroline Malnoë et Geneviève Gésan-Guiziou**  
(INRAE), **Julien Hilaire** (DEVHIL)

FAIRCHAIN project partners, especially WP5 (Karin Östergren,  
RISE)

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# FAIRCHAIN PROJECT

## FINAL EVENT *with 2 parts*

# INVITATION

Bruges Meeting & Convention Centre  
Thursday, 14 November 2024



**1 SPECIAL SESSION**  
*Paving the Way to Sustainable and Innovative Intermediate Food Value Chains: Learning from FAIRCHAIN*

8H30 - 10H00 room 12  
*In the framework of EFFoST Conference*  
Mandatory registration **here** at **EFFoST** website

Focus on the **FAIRCHAIN achievements and lessons learnt** on:

- ▶ innovations
- ▶ methodology
- ▶ policy recommendations

*After the EFFoST closing session join us for a*  
**NETWORKING FORUM with**  
**FREE lunch**

## NETWORKING FORUM

13H30 - 16H00 room 6  
**FREE EVENT!** Registration required **here** → 

- ▶ Meet the team
- ▶ Uncover the ways to develop Intermediate Food Value Chains
- ▶ Enjoy a free tasting of food and drinks produced through FAIRCHAIN innovations.

**More information:** [www.fairchain-h2020.eu/final-events/](http://www.fairchain-h2020.eu/final-events/)



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