ProScale Service Life: Assessing Direct Use-Phase Exposure in Early Innovation

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Life cycle-aware innovation drives more competitive product design

- Innovation requires assessment of multiple parameters to prepare the product for the future market
- Safety and sustainability aspects become more important:
  - Goodwill and reputation
  - Economy and efficiency!
- The Safe and Sustainable by Design (SSbD) framework support in decision making to guide design choices aiming for long-term competitiveness

- Avoid regrettable substitution
- SSbD framework requires tools capturing toxicological impacts of chemicals from a life cycle perspective to guide innovation
- Identifying toxicological impacts on consumers during the use phase of products is difficult:
  - Lack of tools
  - High uncertainty and variability
  - A lot of unknowns

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- Safety and sustainability aspect… more important:
  - Goodwill an…
  - Economy and …
- The Safe and Sustainable by Des… (SSbD) framework support in decision making to guide design choices aiming for long-term competitiveness

Approach: ProScale-SL (Service Life) applied in early innovation

- Avoid regrettable substitution
- SSbD framework requires tools capturing toxicological impacts of chemicals from a …erspective to guide innovation
- …mpacts on …phase of …tools
  - High uncertainty and variability
  - A lot of unknowns

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ProScale is a chemical footprinting method to assess products' (eco)toxicity potential

- Proscale is a regulatory-aligned, risk-based chemical footprinting method to assess product/process/system (eco)toxicity potential from a life cycle perspective

ProScale

- 1st version developed by the ProScale consortium during 2015-2017
- Idea: Capture LCA compatible toxicological impact potential from direct exposure to hazardous substances along the entire life cycle of a product, by describing inherent toxicity via a hazard score and the exposure potential, based on easily retrievable information (e.g. REACH)
- Recent development: Expansion of the method to better guide assessment of the use phase (ProScale-SL) as well as indirect exposure to humans via the environment (ProScale-IE)

Do you want more insight in the ProScale methodology? Visit poster presentations 6.07.P-Th250 and 6.07.P-Th251, and look into 5.10.P-Mo378!

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ProScale-SL assess direct impact from chemicals to humans during the use phase of products

Imported from Consumer TRA

$$ProScale = \sum_{\substack{Substances \\ Exposure\ routes \\ Archetypal\ environments}} \left(\frac{HF \times PPDD \times PHF}{m_{ref}} \right) \times MF$$

CF

HF: Hazard Factor (unitless)
PPDD: Per Person Daily Dose (mg · person^{-1} · day^{-1})
PHF: Person-Hour Factor (person-days)
mref: Reference mass flow (kg)
MF: Mass Flow (kg)

- Substance specific
- Product specific
- Archetypal Indoor Environment-specific
- Product system dependent

H-phrase=Hazard phrase. OEL=Occupational Exposure Limit. DNEL=Derived No Effect Level. CF=Characterization factor.

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$$ProScale = \sum_{\substack{Substances \\ Exposure\ routes \\ Archetypal\ environments}} \left(\frac{HF \times PPDD \times PHF}{m_{ref}} \right) \times MF$$

Archetypal Indoor Environments (AIEs) standardize human time associated with the product's service life environment

Person-hour factor (PHF): captures the exposure of all consumers in an archetypal indoor environment (AIE) and the functional unit time horizon

AIEs are derived based on normative building standards and recommendations for different indoor environments

Per person daily dose (PPDD): represents the daily exposure per person

$$PHF = \text{People Density (persons/m}^2\text{)} \times \text{Environment Surface Area (m}^2\text{)} \times \text{Time Per Person Year (days/year/person)} \times \text{Functional Unit Horizon (years)}$$

People Density (persons/m²)
- Office: 0.1
- Household: 0.04
- Car: 0.2

Environment Surface Area (m²)
- Office: 100
- Household: 50
- Car: 6

Time Per Person Year (days/year/person)
- Office: 220
- Household: 330
- Car: 150

Functional Unit Horizon (years)

Archetypal Indoor Environment-specific

Product system dependent

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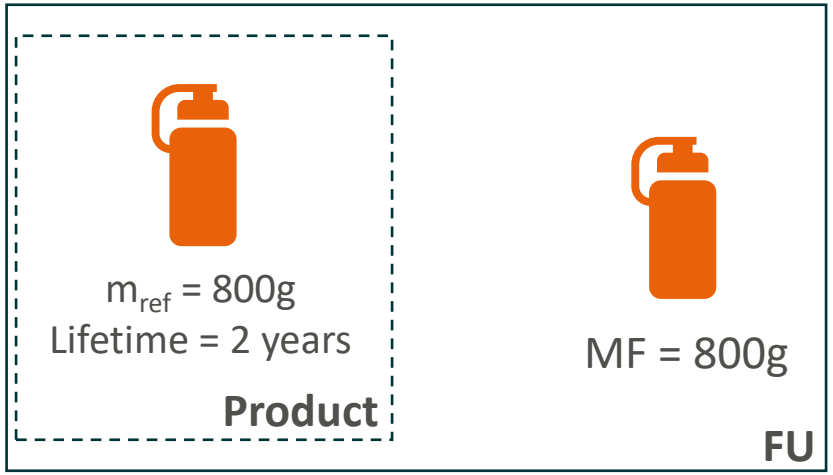
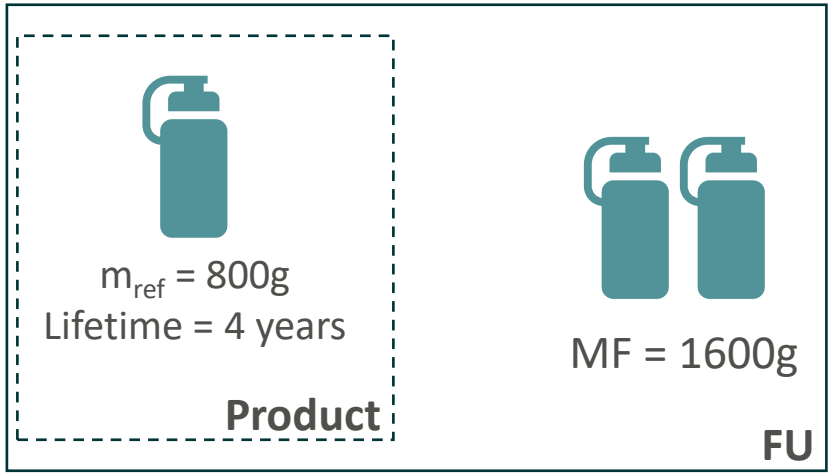
Showcasing the ProScale-SL module by applying it to the use phase of plastic bottles

- Fictive case study with low data availability, borrowed and modified from the PARC BPA case study
- Parameters
  - FU: 1 bottle, 0.8 kg, washed manually 25 times
  - AIE: household
  - Composition: BPA-based PC bottle





Example

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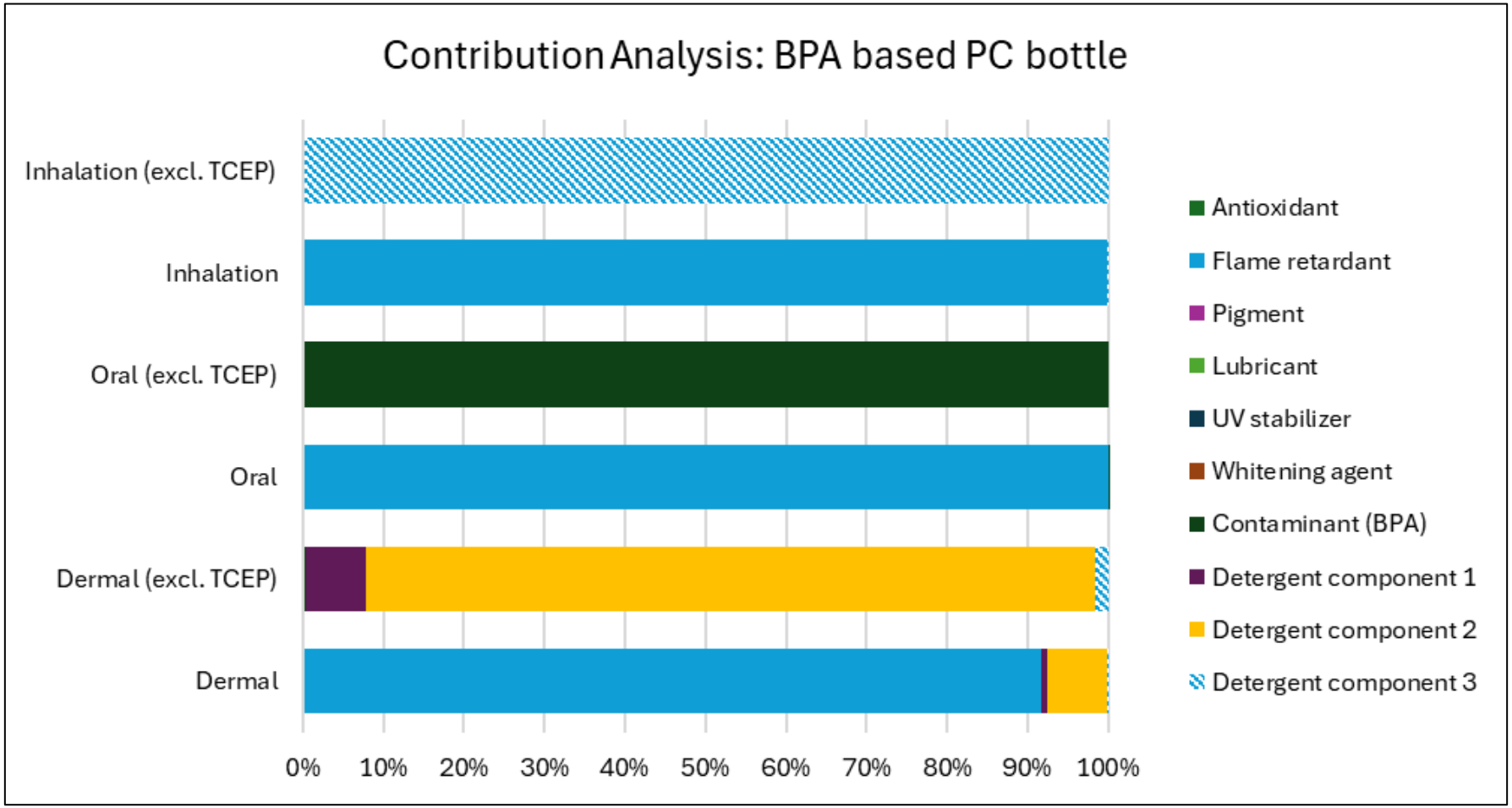
Applying ProScale-SL to the use phase of a consumer product shows that the potential impact is driven by the substance of very high concern (SVHC)



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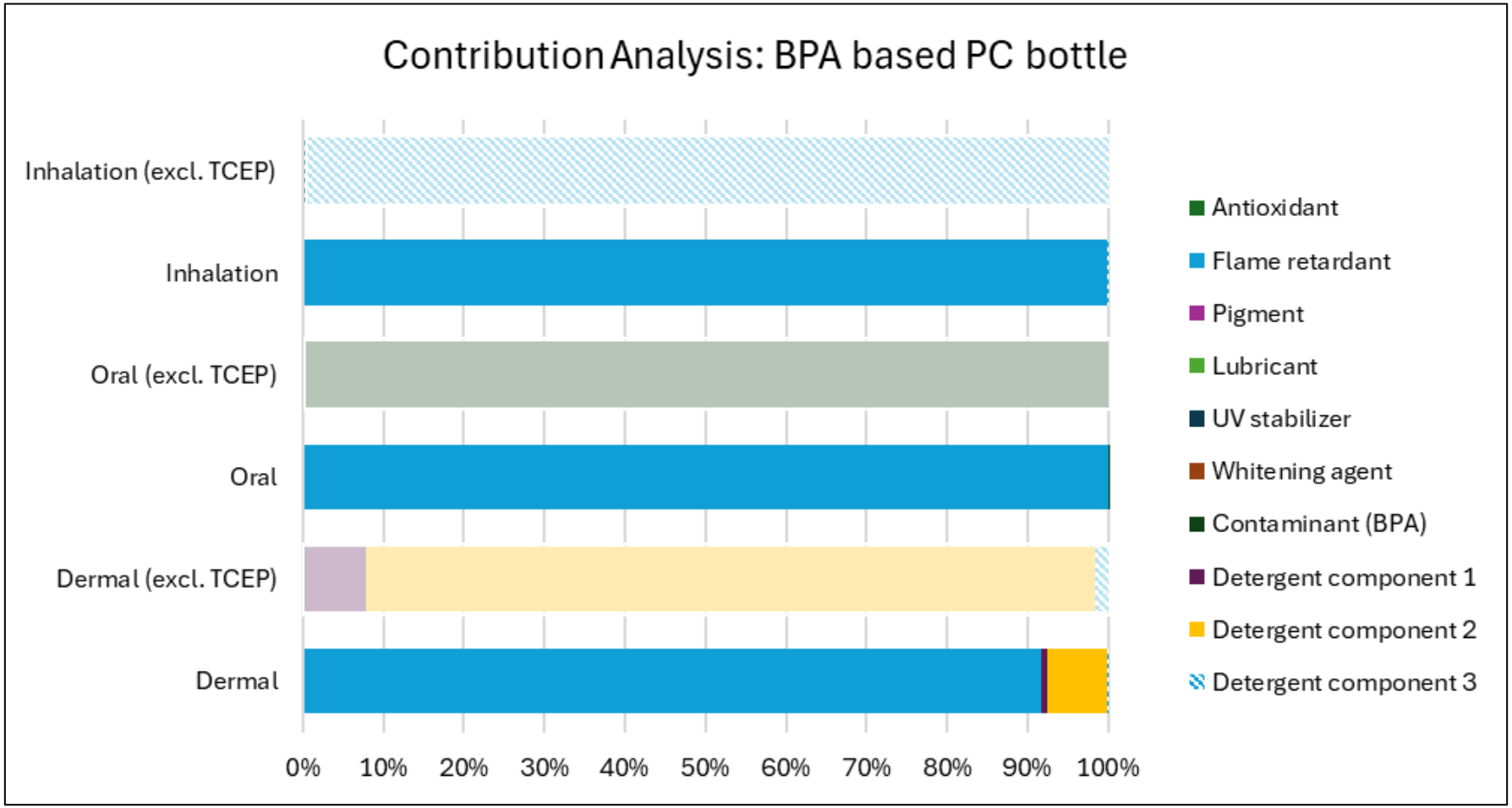

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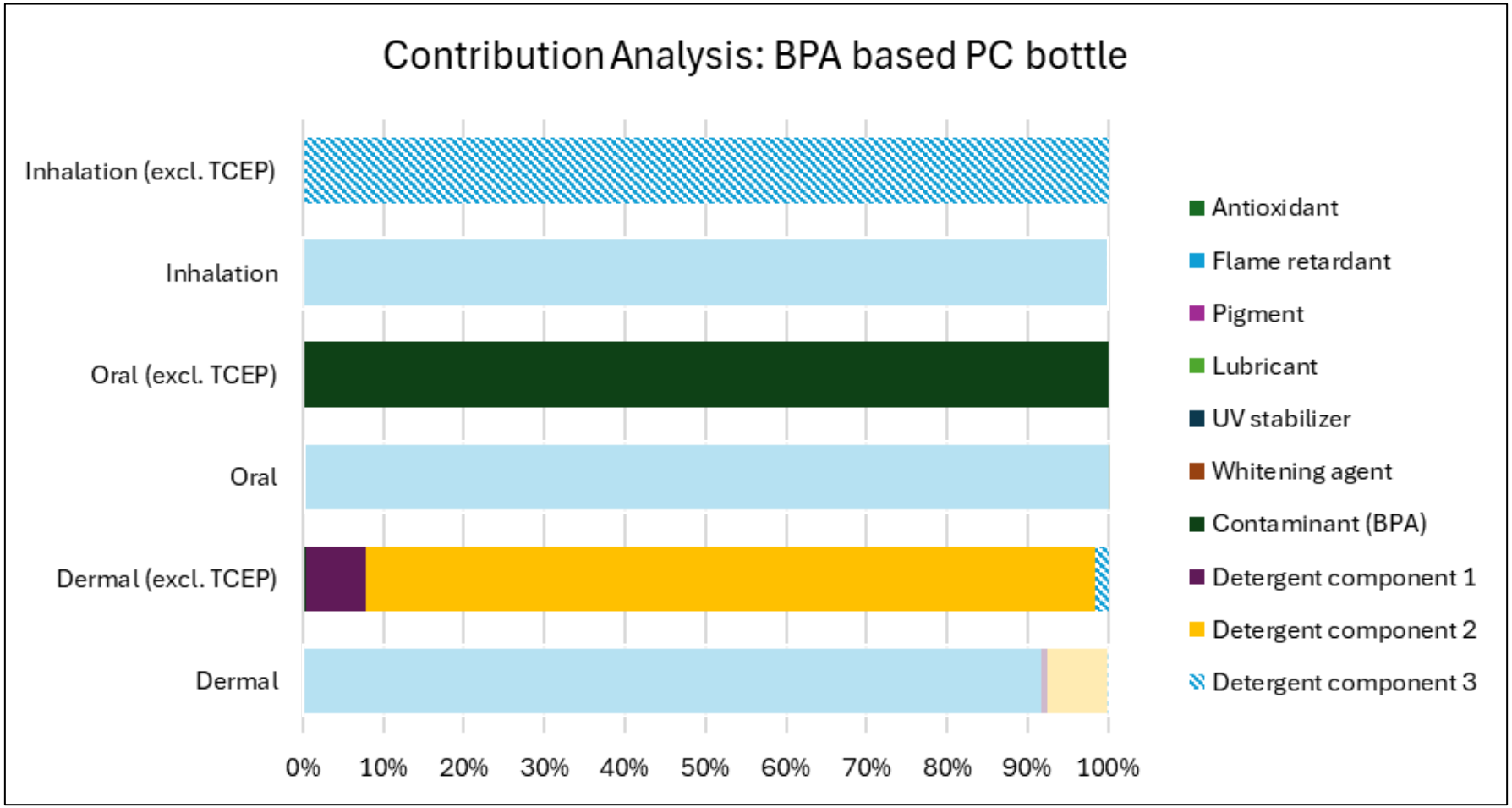

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Key messages

ProScale Service Life…

…enables safe and sustainable innovation by identifying toxicological hotspots in the use phase

…fills the gap of tools needed to assess toxicological impacts with life cyle perspective in the use phase

…creates awareness of toxicological risks, which enables choosing safer and more sustainable alternatives

...avoids regrettable substitution in early innovation when applied within the SSbD context

Thank you for your attention!

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ProScale Service Life

Default Settings:

H-phrases + OEL/DNEL

Consumer TRA

Defined for AIE

”Bill-of-material”

$$\text{ProScale} = \sum_{\substack{\textit{substances} \\ \textit{exposure routes} \\ \textit{archetypal environments}}} \left(\frac{\textbf{HF} \times \textbf{PPDD} \times \textbf{PHF}}{\mathbf{m_{ref}}} \right)_{CF} \times \textbf{MF}$$

HF
Hazard Factor
Substance hazard, based on H-phrase and OEL

PPDD
Per person daily dose
Modelled exposure

PHF
Person-Hours Factor

m_{ref}
Reference flow
Mass of one product unit

CF

MF
Mass Flow
Inventory mass flow or products over the functional unit horizon

Substance specific | Product specific | Product system dependent | AIE specific

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ProScale Service Life

$$ProScale = \sum_{\substack{Substances \\ Exposure\ routes \\ Archetypal\ environments}} \left(\frac{HF \times PPDD \times PHF}{m_{ref}} \right) \times MF$$

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Hazard Factor, HF

The HF describes the health hazard, per exposure route, of a substance based on:

- Hazard phrases (H-phrases) as in the Globally Harmonised System (GHS) and the EU CLP regulation*, which have been grouped into hazard classes which has a numerical value
- Occupational Exposure Limits (OELs) or if not available, Derived No Effects Levels (DNELs). In ProScale the OELs/DNELs reflect the potency of a substance.

ProScale hazard class	H-phrases according to GHS/CLP, grouped per exposure route
E – "CMR" 10 000 – 100 000 (highest hazard)	All routes: H340, H350, H360, EUH380**, EUH440**, **EUH441**
D – "Fatal" 1 000 – 10 000	Dermal: H310 Inhalation: H330, H334, EUH032 Oral: H300 All routes: H341, H351, H361, H362, H372, EUH381
C – "Toxic" 100 – 1 000	Dermal: H311, H314, H317, H318, EUH070 Inhalation: H331, EUH029, EUH031, EUH071 Oral: H301, H304 All routes: H370, H373
B – "Harmful" 10 – 100	Dermal: H312, H315, H319 Inhalation: H332, H335 Oral: H302 All routes: H371
A – "Maybe harmful" 1 – 10 (lowest hazard)	Dermal: H313, H316, H320, EUH066 Inhalation: H333, H336 Oral: H303, H305

*Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP Regulation)

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Per Person Daily Dose, PPDD

In ProScale Workers exposure is captured via the ECETOC Targeted Risk Assessment (TRA) model, thus for the service life the ECETOC Consumer TRA model was selected to capture exposure.

Benefits Consumer TRA:

- Covers a wide scope of Product and Article Categories (PCs, ACs)
- Uses minimal input to suit the needs for ProScale Service Life (Pvap, Product Ingredient Fraction by Weight)
- Daily systemic exposure estimates (mg/kg/day, mg/m3) for each exposure route.

DEFAULT VP (non-spray)					
CLASSES		Default Vapour Pressure Band (non-spray)	Default fraction released to air		
A		A: Vapour pressure >= 10 Pa	1		
B		B: Vapour pressure between 1 and 10 Pa	0.1		
C		C: Vapour pressure between 0.1 and 1 Pa	0.01		
D		D: Vapour pressure < 0.1 Pa	0.001		
Vapour Pressure (Pa)					
Reference Value (Inhalation)		mg/m^3			
Reference Value (Inhalation)		mg/kg/day			
Reference Value (Dermal)		mg/kg/day			
Reference Value (Oral)		mg/kg/day			
Molecular weight		g/mol			
Saturated vapour concentration (SVC)	0.00E+00	mg/m3			
	Use "x" only		**Use "x" only**		
Descriptor	**Select Use by Sentinel Product**	**Product Subcategory**	**Select Use by Product Subcategory**	**Product is a spray**	**Product Ingredient Fraction by Weight**

Source: ECETOC Consumer TRA Excel-spreadsheet. Available from: ECETOC website

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$$ProScale = \sum_{\substack{Substances \\ Exposure\ routes \\ Archetypal\ environments}} \left(\frac{HF \times PPDD \times PHF}{m_{ref}} \right) \times MF$$

Person-Hours Factor, PHF, and Archetypal Indoor Environments, AIEs

The PPDD represents the daily exposure per person, the person-hour factor (PHF) is used to capture the exposure of all consumers in an archetypal indoor environment (AIE) and the functional unit time horizon.

AIEs are derived based on e.g. normative building standards and recommendations for different indoor environments.

$$PHF = \text{People Density (persons/m}^2\text{)} \times \text{Environment Surface Area (m}^2\text{)} \times \text{Time Per Person Year (days/year/person)} \times \text{Functional Unit Horizon (years)}$$

People Density (persons/m²)	Environment Surface Area (m²)	Time Per Person Year (days/year/person)	Functional Unit Horizon (years)
Office: 0.1	Office: 100	Office: 220	
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Product system dependent

AIE specific

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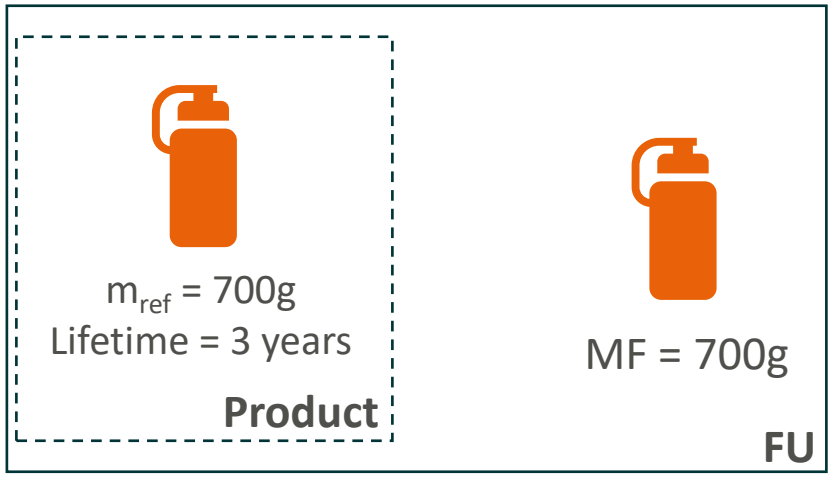
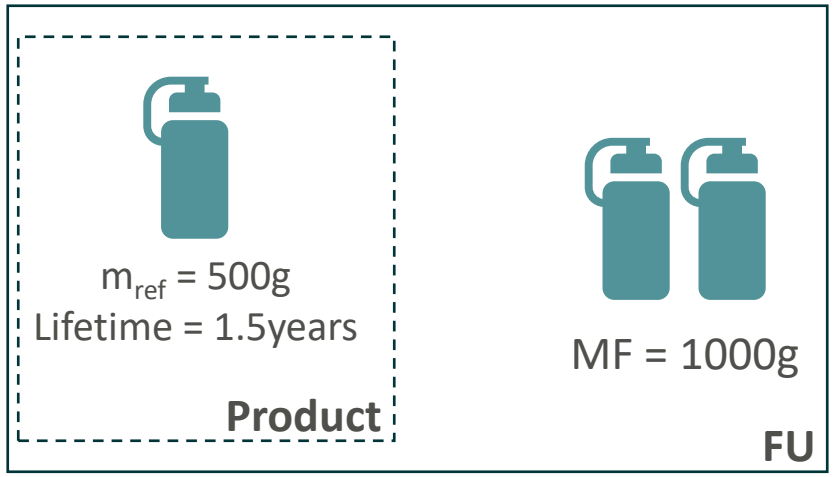
Mass Flow, MF, and Reference – Flow Mass, m_{ref}

The mass flow (MF) captures the total mass products required to fulfill the FU horizon, while the reference-flow mass (m_{ref}) represents the mass of a single product.

Example: Two bottles in different materials during 3 years





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Monte Carlo Analysis of Variable Contributions

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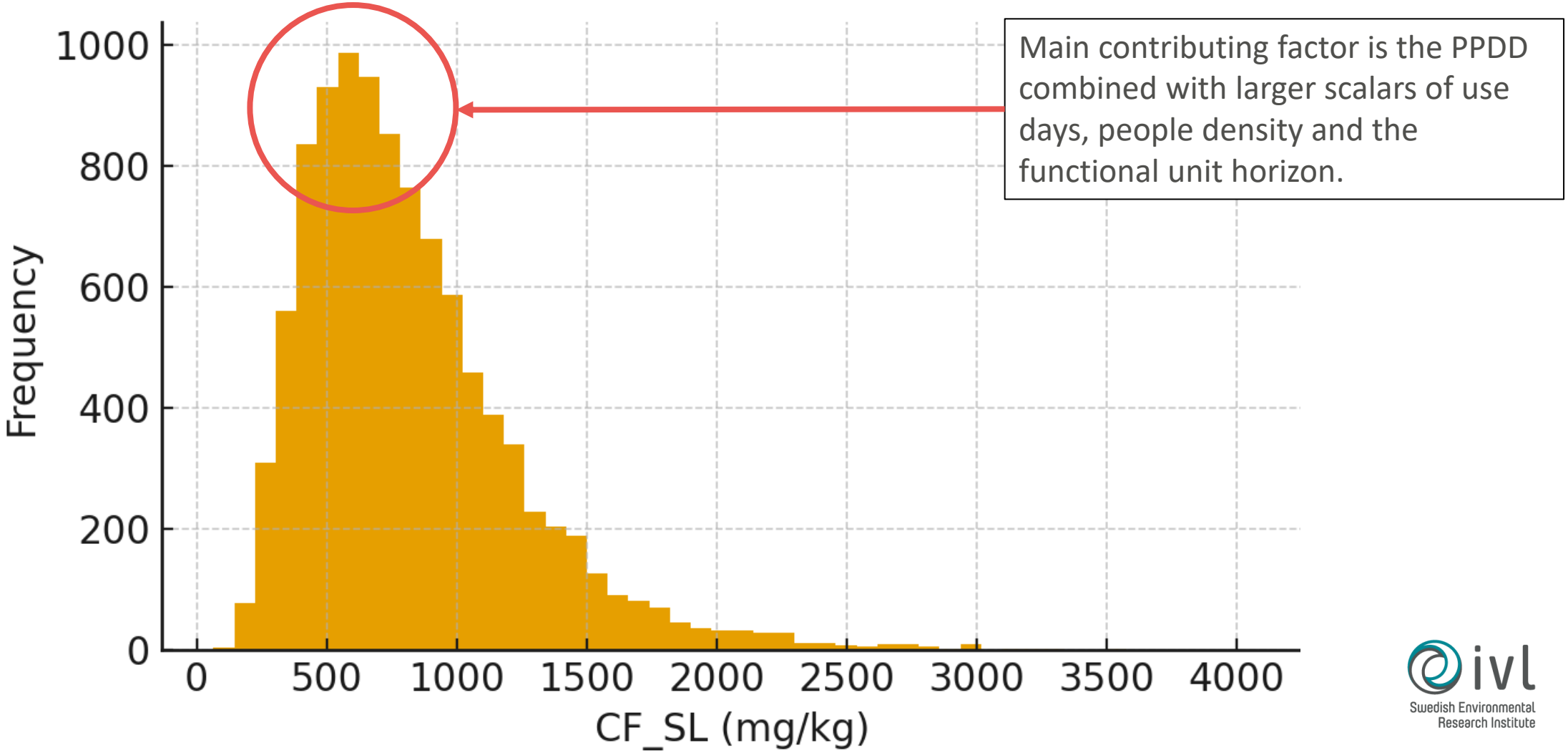

Main contributing factor is the PPDD combined with larger scalars of use days, people density and the functional unit horizon.

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