



SITOLUB

*SIMULATION TOOLS FOR
THE DESIGN OF SAFE AND
SUSTAINABLE LUBRICANTS*

A Parameterised openLCA Model for Flexibly Assessing Lubricant Fate and Re-Refining Feasibility

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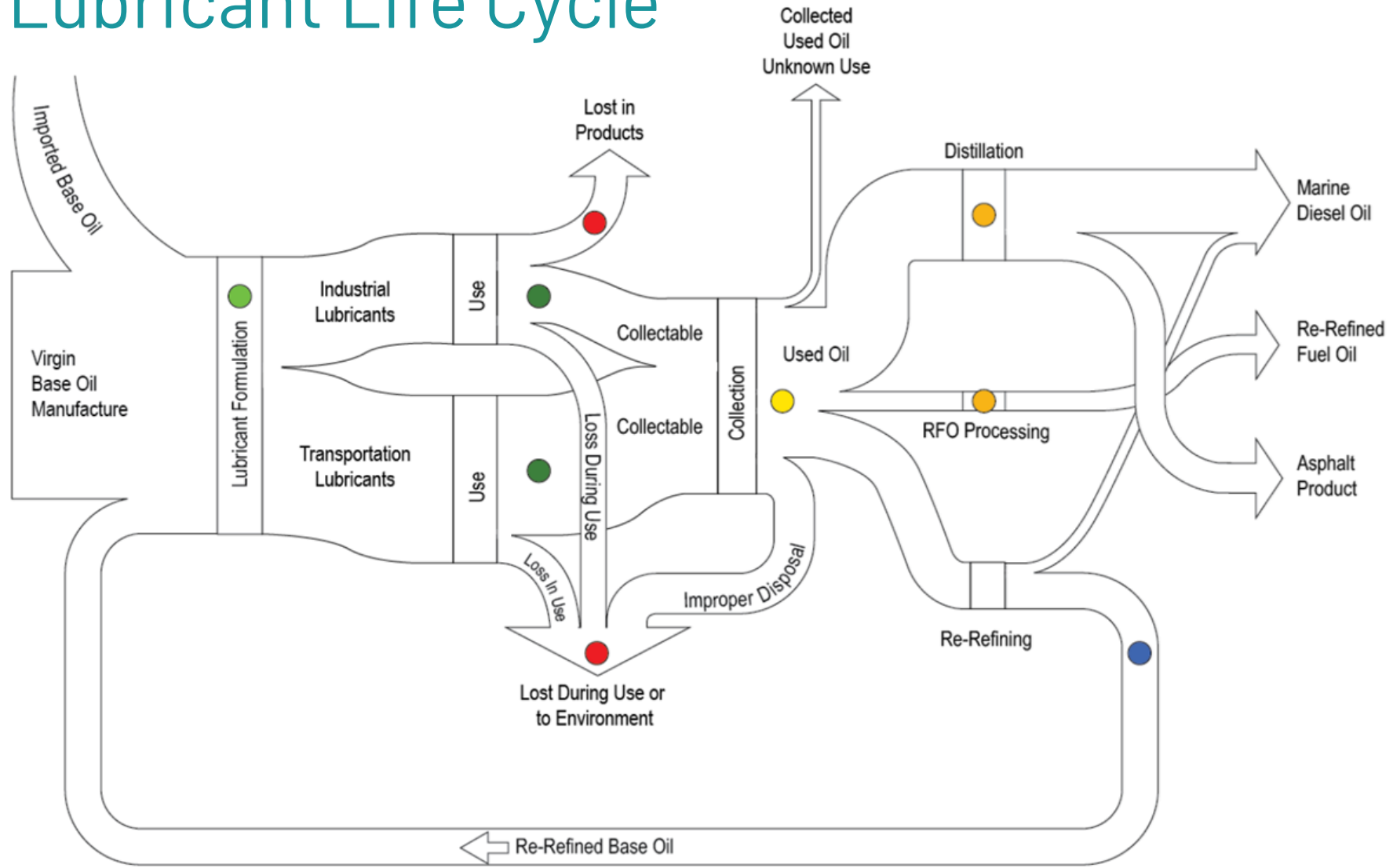
Berlin, Germany

GreenDelta

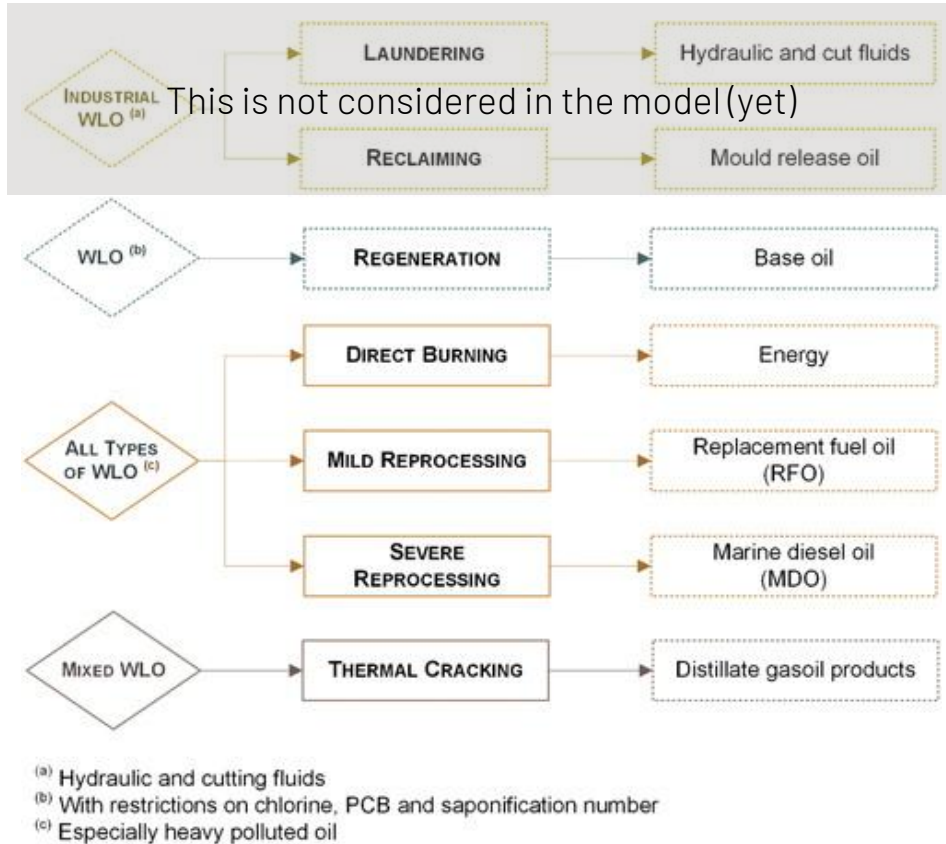
Introduction

- Lubrication enables key mechanical processes that keep the economy running smoothly
 - SiToLub: Research project focused on improving lubrication chemistry
 - While lubrication may reduce overall environmental impact of processes, involved chemicals are critical → environmental release could occur
- Development of a virtual platform integrating computational models from a variety of fields
 - QSAR, FEM, LCSA, TEA
- Prediction of performance, toxicity, sustainability implications
 - As part of the environmental LCA: flexible modelling approach dependent on lubricant formulation to estimate fate

The Lubricant Life Cycle



WLO End-of-Life treatment options

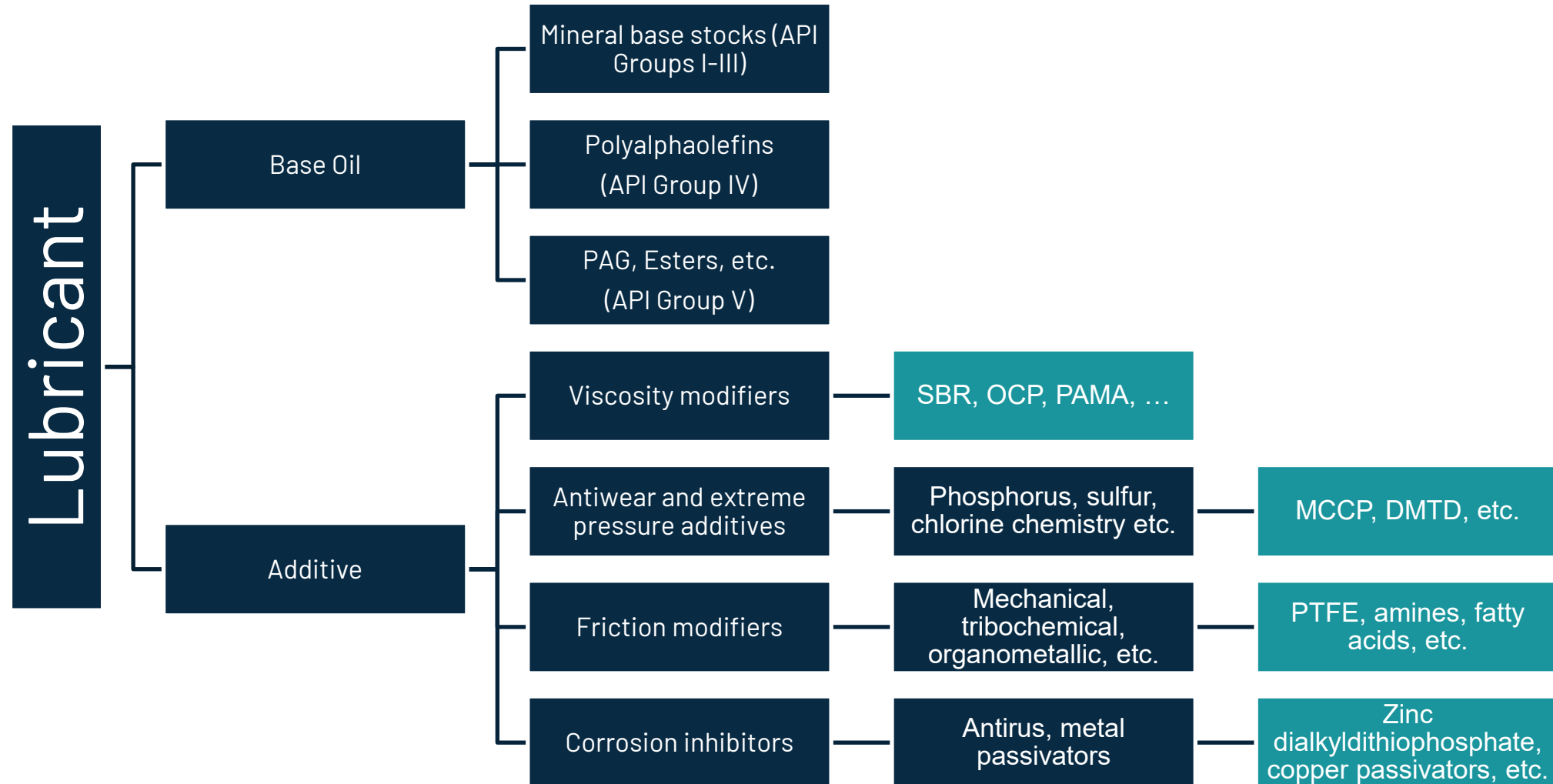


Re-refining	Solvent extraction <small>Botas et al. (2017)/ Fehrenbach (2005)</small>	HP Hydro-treatment <small>Fehrenbach (2005)</small>	Distillation <small>Fehrenbach (2005)</small>	Acid-clay <small>Not modelled (lack of relevance for European context)</small>
Fuel conversion	Marine fuel oil <small>García-Gutiérrez et al. (2025)/ Pires et al. (2013)</small>	Replacement fuel oil <small>García-Gutiérrez et al. (2025)/ Abdalla & Fehrenbach (2018)</small>	Gasification <small>Not modelled</small>	
Energy recovery	Cement kilns <small>García-Gutiérrez et al. (2025)/ Pires et al. (2013)</small>	Lime works <small>Not modelled</small>	Power plant / incineration <small>García-Gutiérrez et al. (2025)/ ecoinvent / Pires et al. (2013)</small>	Expanded clay <small>Pires et al. (2013)</small>
Haz. waste incineration	With energy recovery <small>García-Gutiérrez et al. (2025)/ ecoinvent</small>	W/O energy recovery <small>García-Gutiérrez et al. (2025)/ ecoinvent</small>		

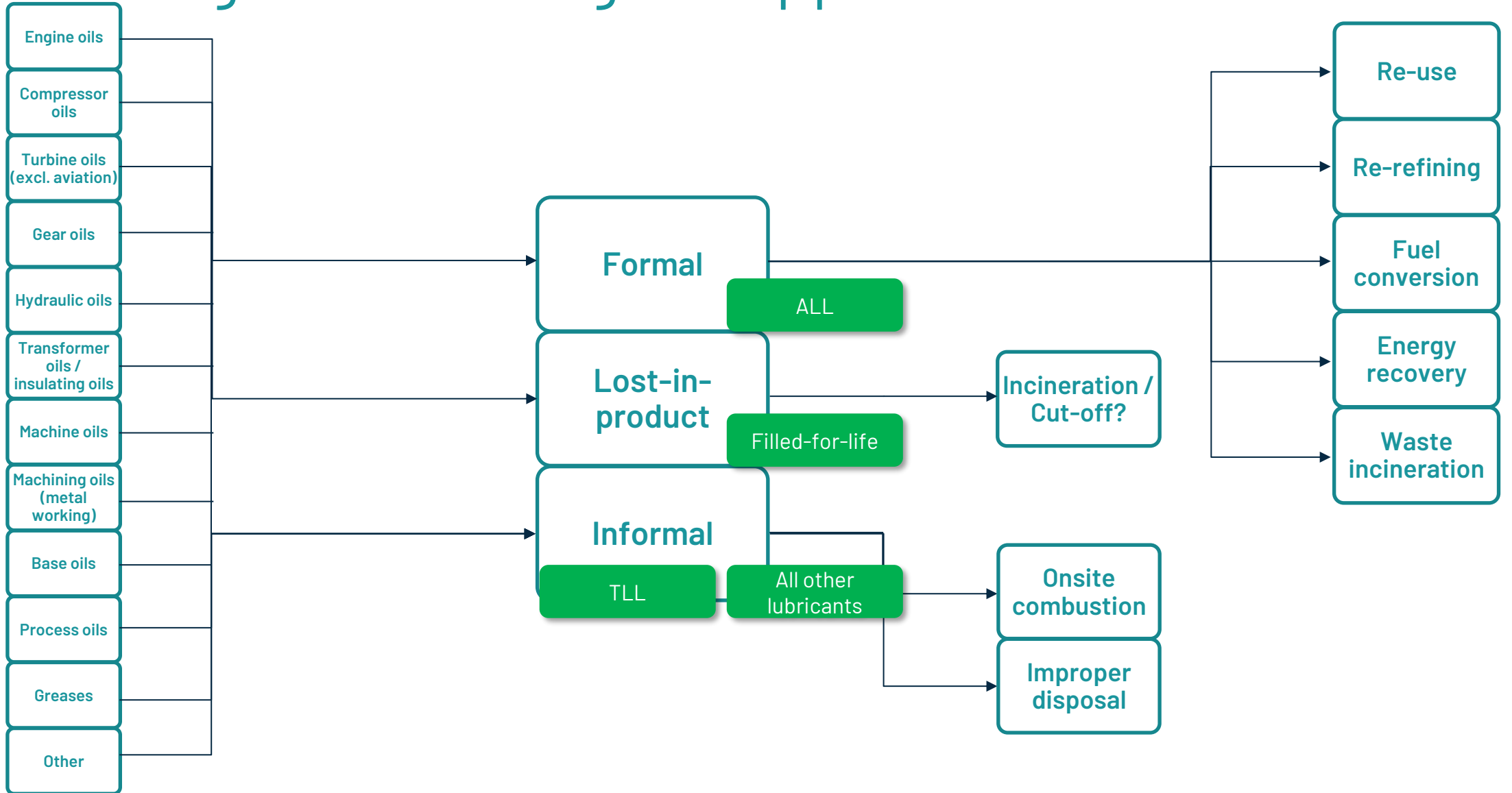
Stahl, H., & Merz, C. (2020). Study to support the Commission in gathering structured information and defining of reporting obligations on waste oils and other hazardous waste (No. 07.0201/2018/789021/ENV.B.3). Oeko-Institut e.V. <https://op.europa.eu/en/publication-detail/-/publication/73a728bc-72f5-11ea-a07e-01aa75ed71a1/language-en>

Pinheiro, C. T., Quina, M. J., & Gando-Ferreira, L. M. (2021). Management of waste lubricant oil in Europe: A circular economy approach. *Critical Reviews in Environmental Science and Technology*, 51(18), 2015–2050. <https://doi.org/10.1080/10643389.2020.1771887>

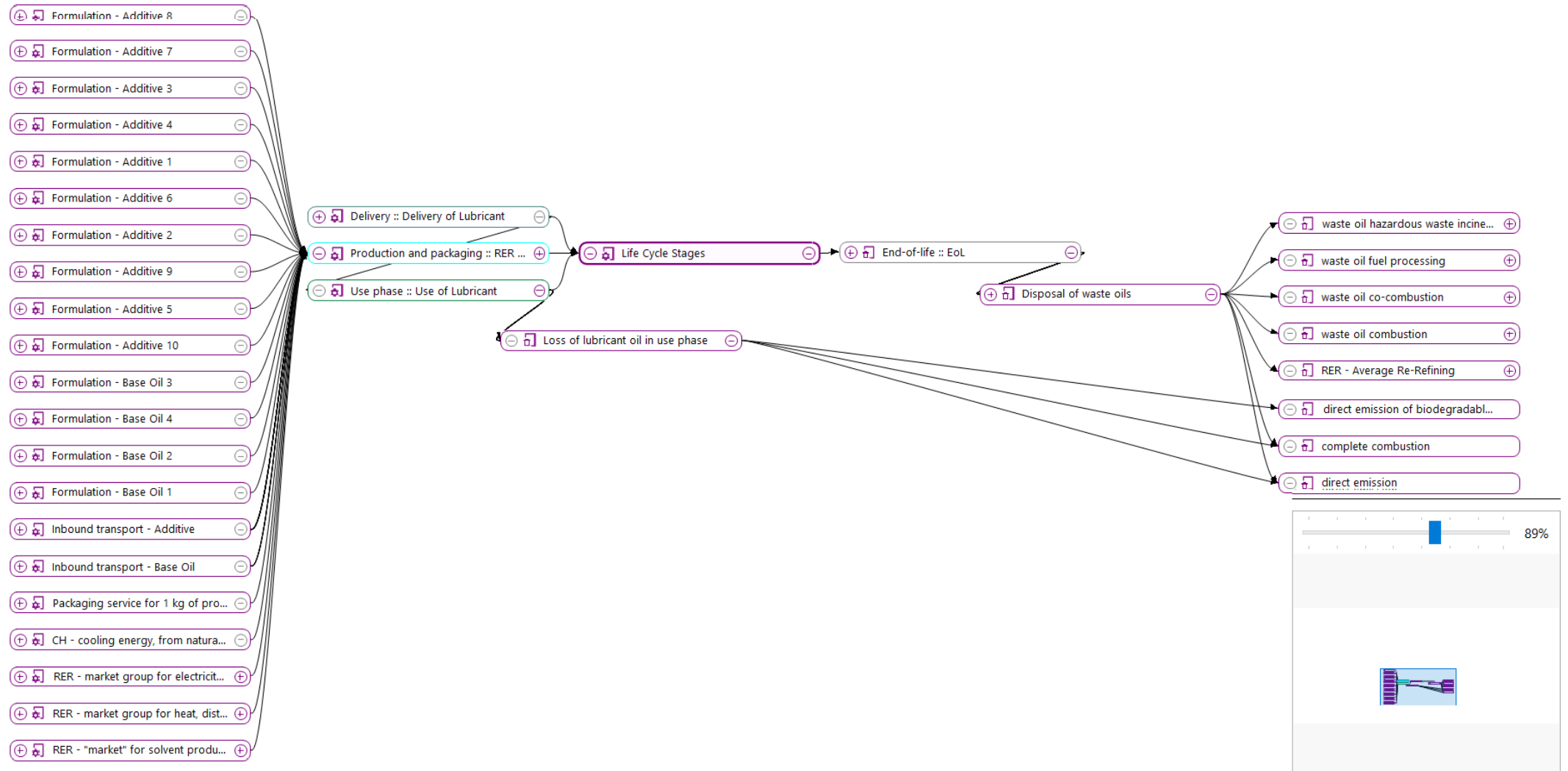
Challenges: chemical space of the SiToLub project

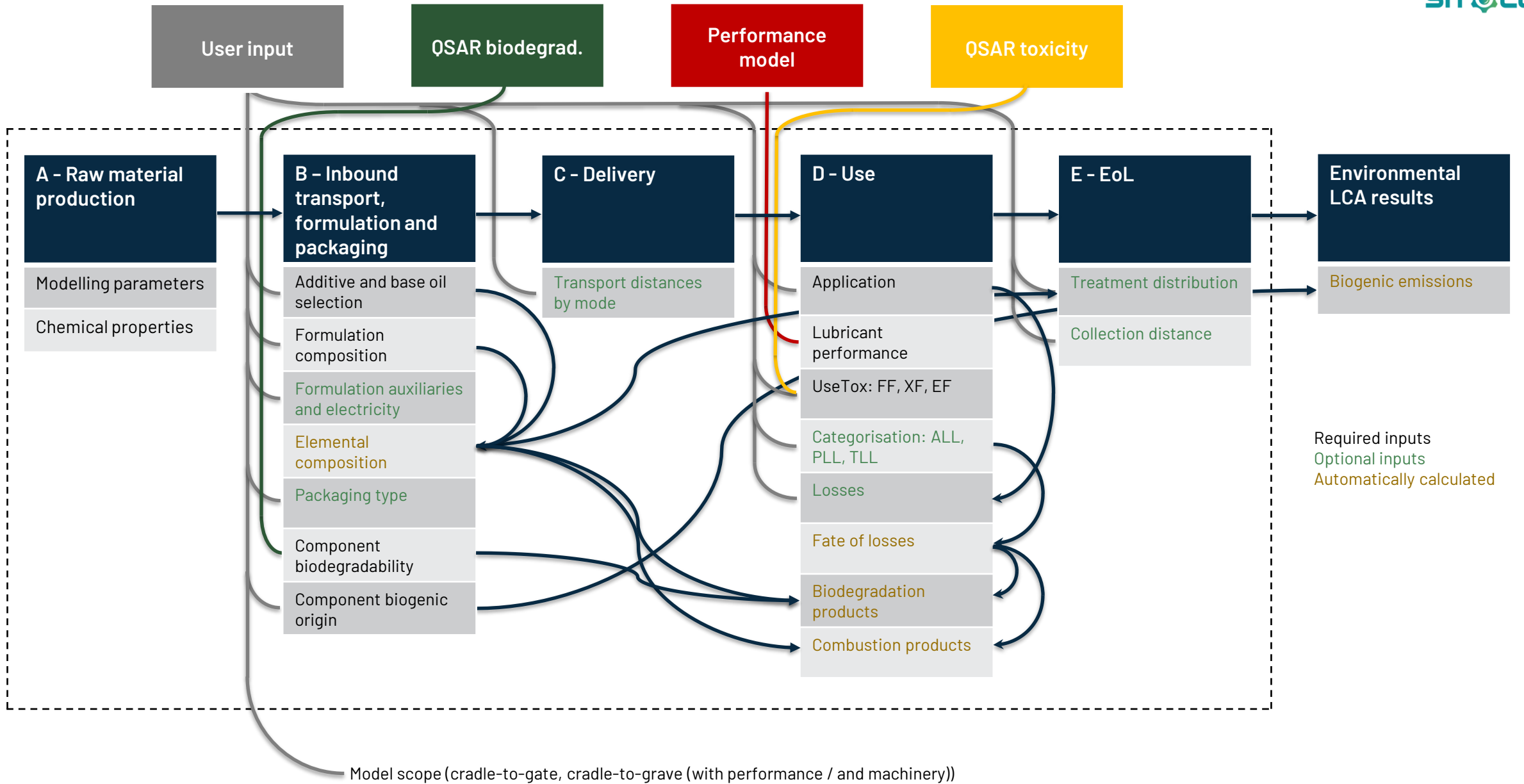


Challenges: wide range of applications

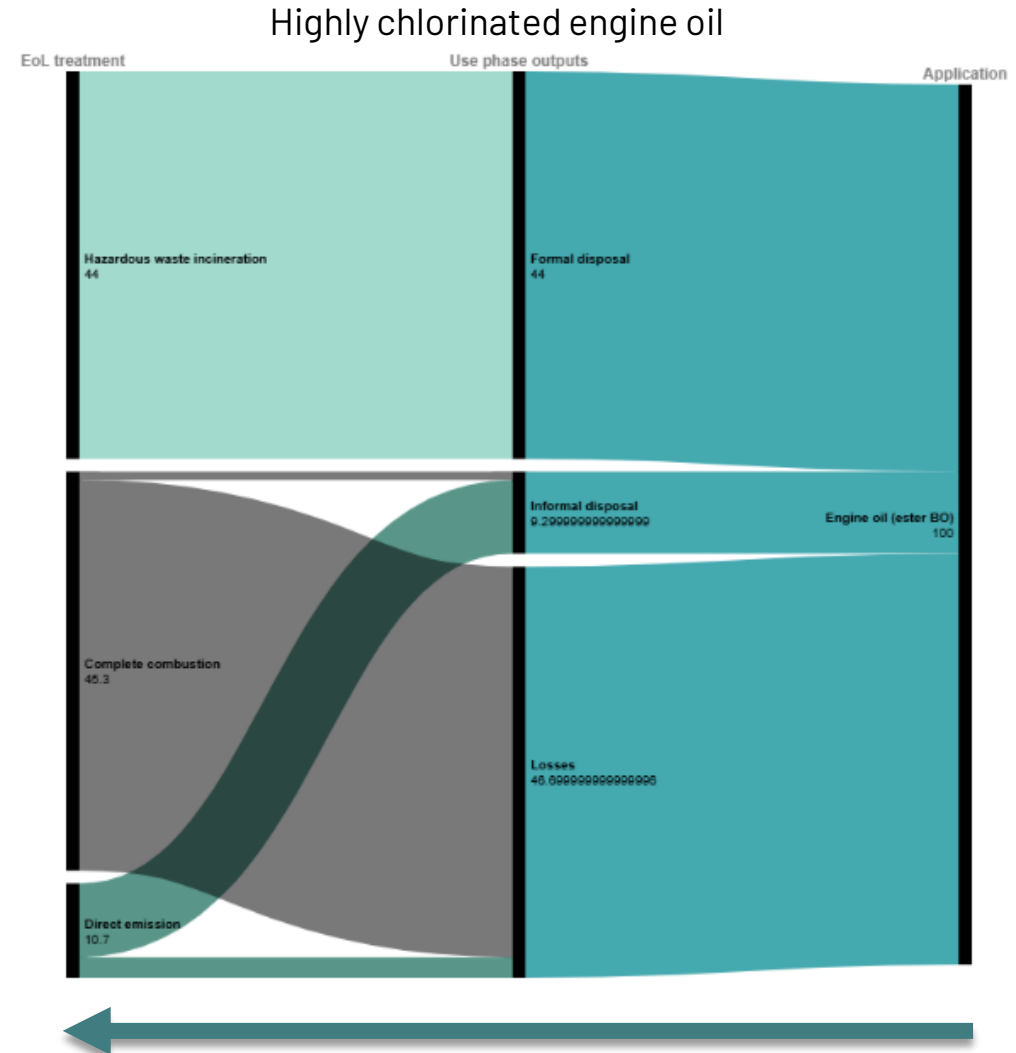
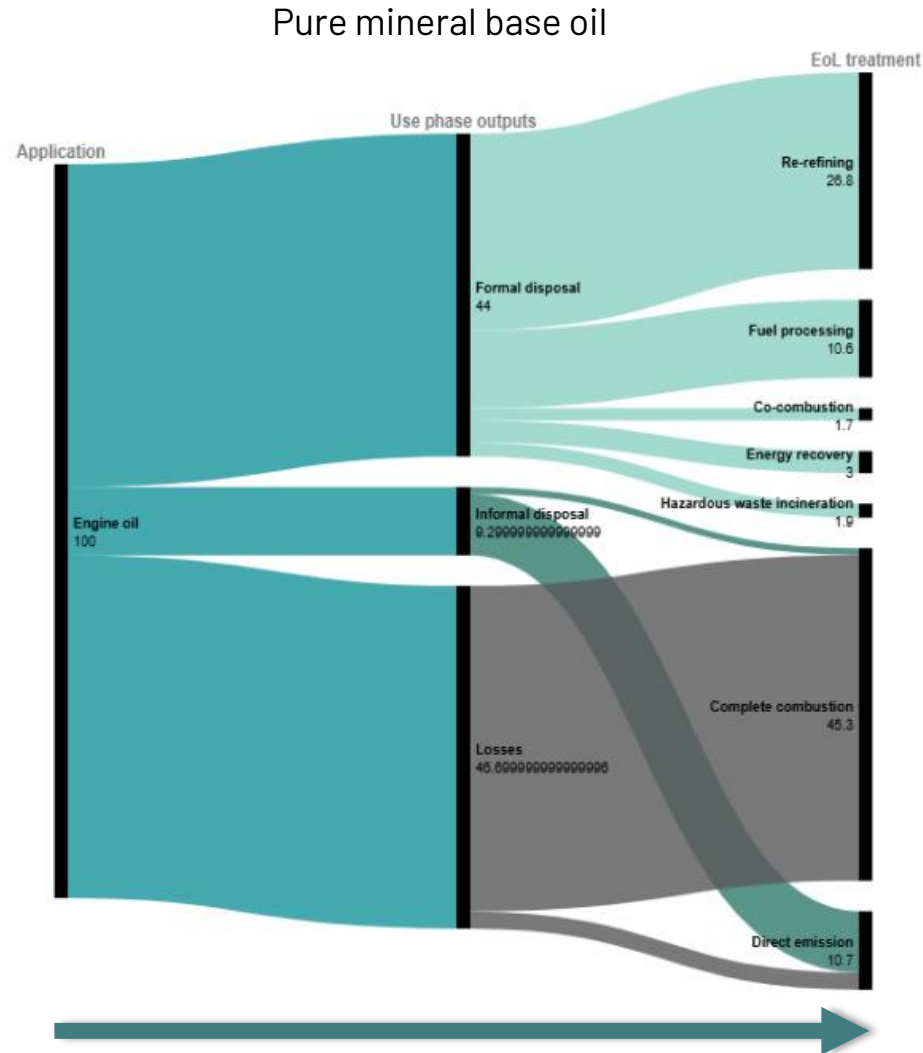


Overview of the openLCA model

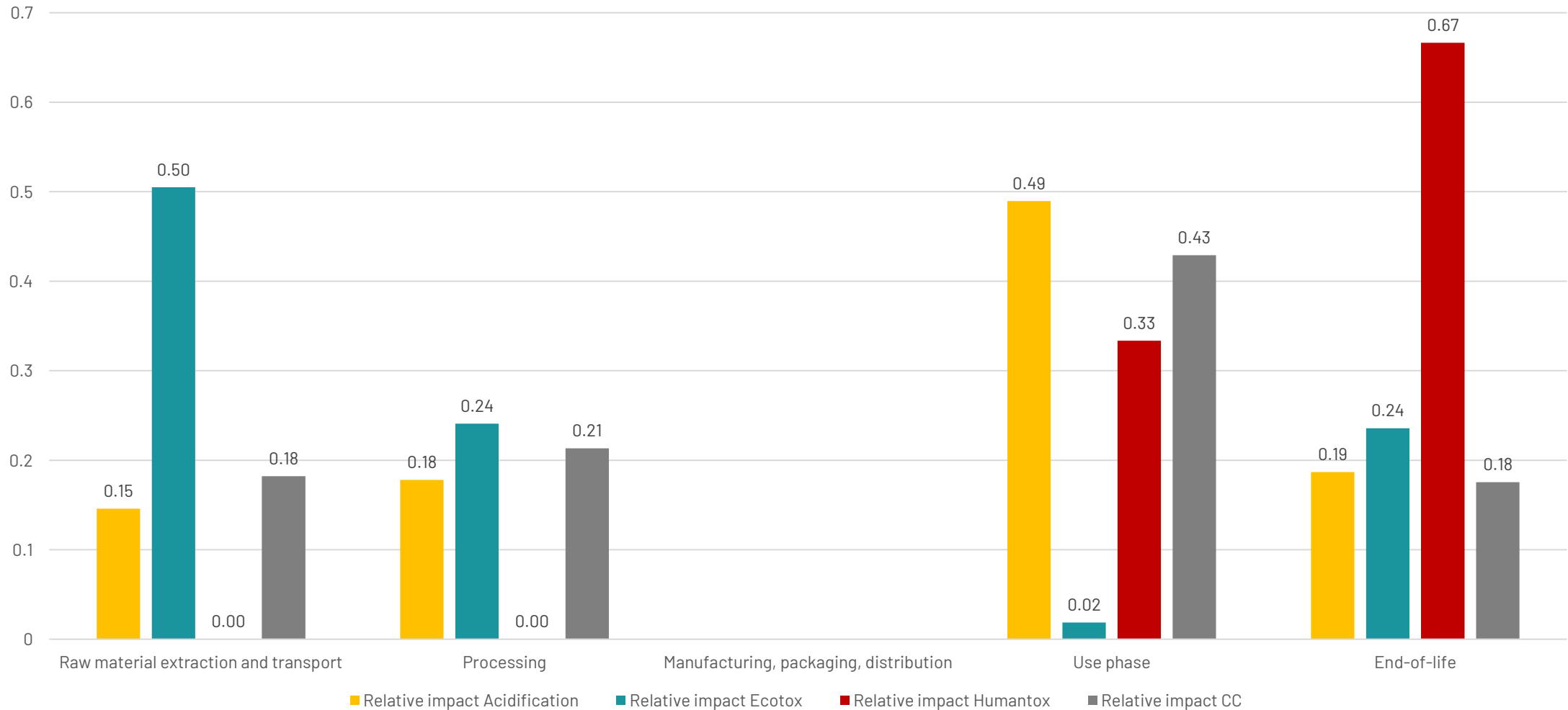




Exemplary fate of potential formulations



Whole life cycle - qualitative validation



Conclusion and outlook

- The SiToLub model demonstrates a highly flexibly modelling approach relevant to lubricants
 - Primary risks can be quantified with the model
- The current model is based on significant assumptions and uncertain data
 - Modelling of direct emissions could be improved by incorporating fate
 - Modelling of formal waste treatment options is generic, adaptation to chemistry would be the next step
- Full automation for novel chemistry will be implemented