Model-based LCSA for plastics and recycled content

J. Cilleruelo Palomero, J. Hoffmann, A. Ciroth
cilleruelo@greendelta.com, GreenDelta GmbH, Berlin

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WWW.PRIMUS-PROJECT.EU

Introduction

Life Cycle Sustainability Assessments usually consider environmental, social and economic perspectives of the life cycle to make decisions about sustainability. This is usually seen as a "full sustainability assessment". However, such **studies look at how the product being assessed affects the environment and society it lives in, but not the other way round:** how does the world's economy, market or consumer behavior, availability of resources, planetary boundaries, etc. affect the results of our sustainability assessment?

As part of the EU-funded project PRIMUS, the usual LCA study is expanded further using System Dynamics modelling. The model serves as a basis to ask questions about recycled content in products. Variables such as ***consumer recycling appreciation***, ***legislation*** for recycled content in plastic products, ***technological potential*** of recycled content integration and ***littering*** are considered.

Reforming secondary plastics to become the first raw material choice of high added value products

PRIMUS

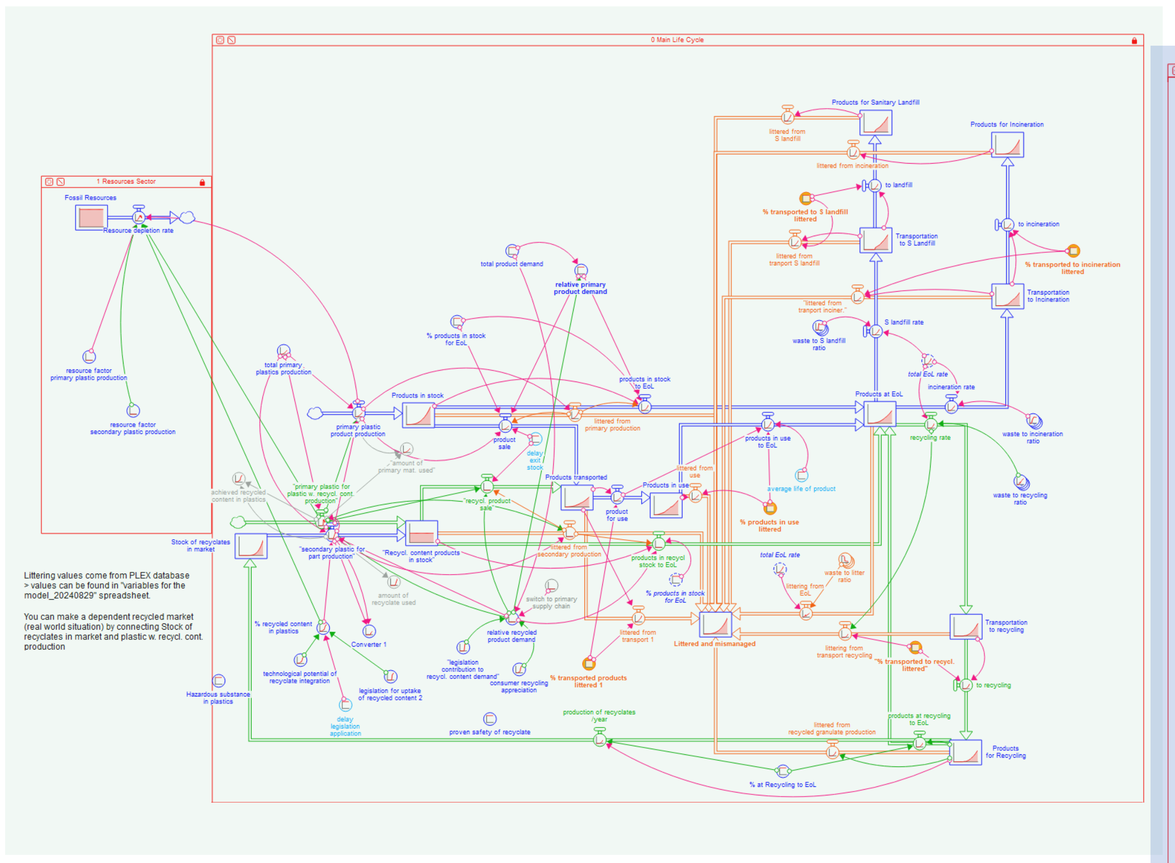
12 European organisations Technology Centres, Universities, Associations, Manufacturing Industry.

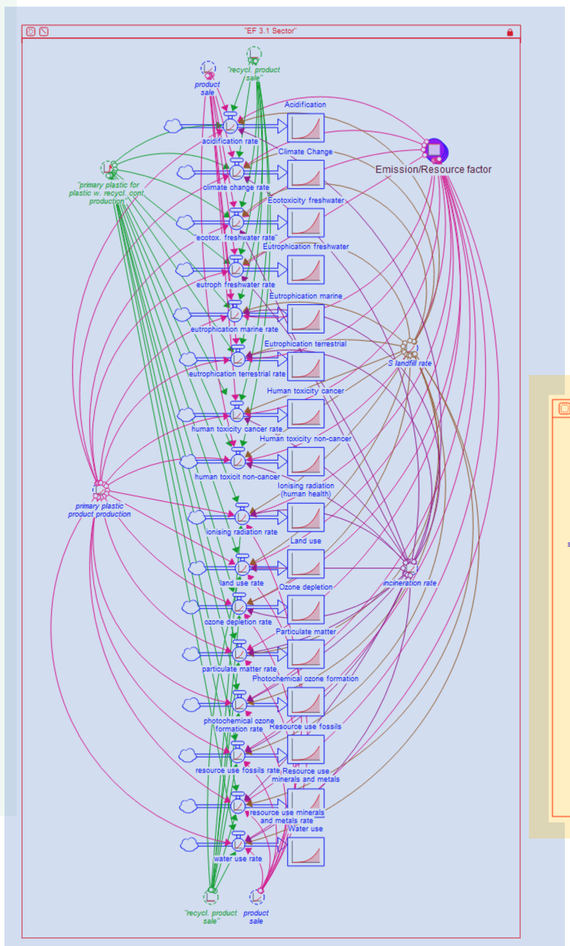
EU funded, 2022-2025

4 demo cases
- *Washing machine seal,*
- *Automotive pipe,*
- *Automotive interior,*
- *Fridge inner part (food contact).*

Methodology

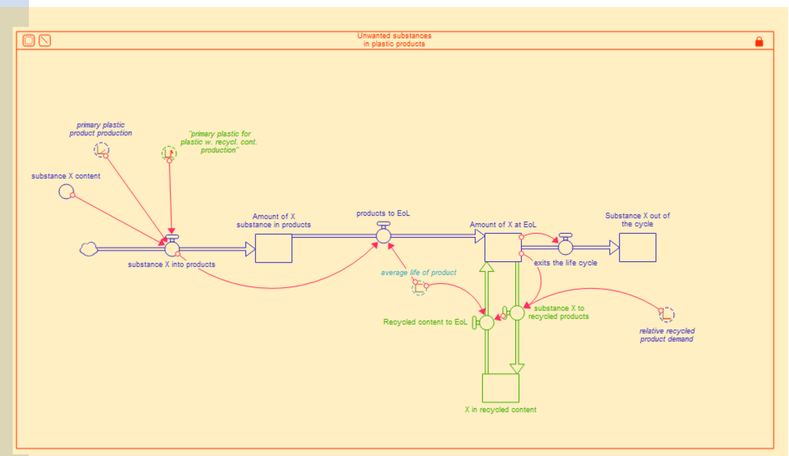
A System Dynamics (SD) model was made using the modelling software Stella Architect 3.5 [1].
The life cycle of plastics was constructed and connected to LCA impact categories and also a side model to assess unwanted substances that remain in the use phase when recycling.
The model was run from the year 1950 to 2060.





Connection to LCA impact categories

Impact factors for different life cycle stages were calculated with ecoinvent 3.10 database, the EF 3.1 LCIA Method and openLCA 2.2 modelling software, then fed into the SD model.



Life Cycle of plastics + Recycling + Litter

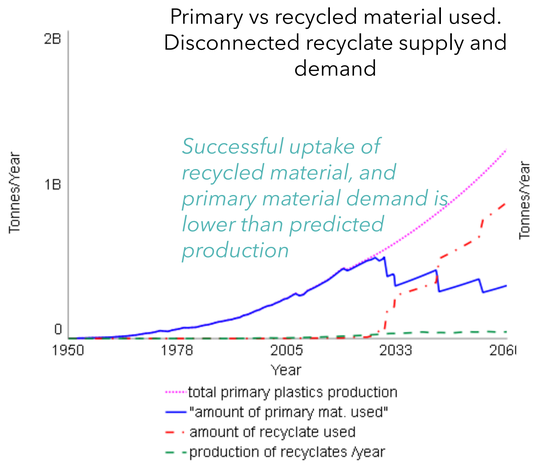
OECD data from the Global Plastics Outlook [2] was inputted at plastic production and end-of-life rates. The probability of plastic littering was obtained from the PLEX database [3].
Two main scenarios were assessed:
- No recycled content integrated, and
- Recycled content becomes compulsory by 2030 towards the goal of a Circular Economy.

Unwanted substances

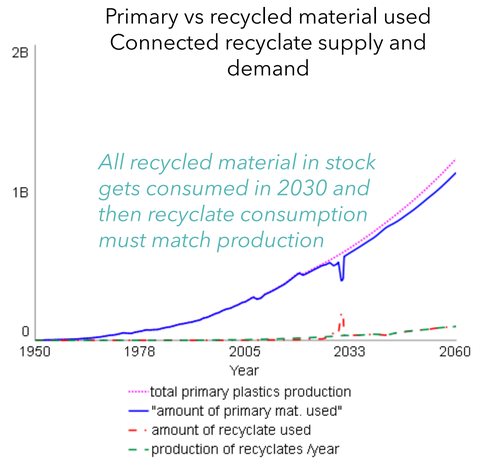
The model was expanded to include a visualization of what happens with substances that were present in older plastic products but banned in the present time, or similar, e.g. UV stabilizers, flame retardants, that remain in recycled content.

Results

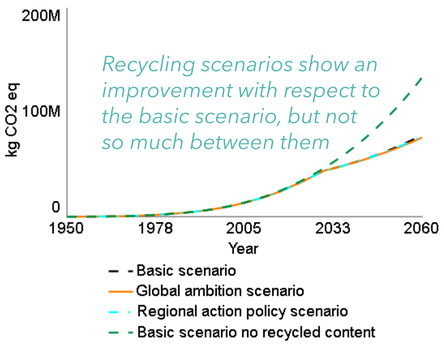
Primary vs recycled material used. Disconnected recyclate supply and demand



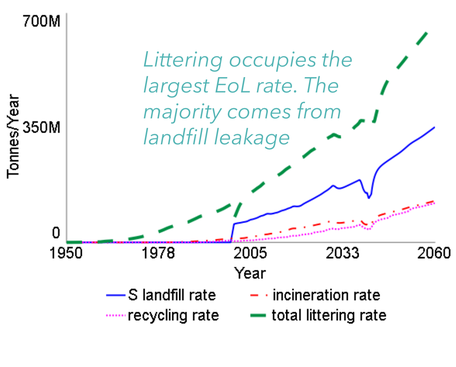
Primary vs recycled material used Connected recyclate supply and demand



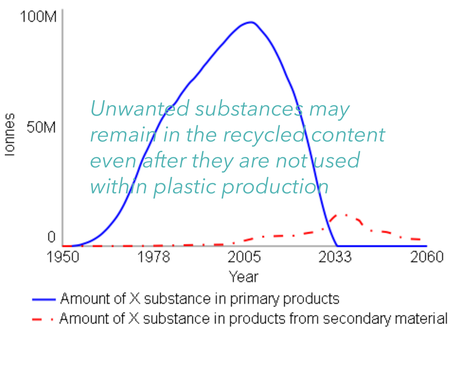
Climate Change results for plastics cradle-to-grave life cycle



EoL fate of plastics



Substance X in use phase of plastics



Conclusions:

1. A growing demand/production of plastics, and not enough recycling rates make a **"Circular Economy" hard to reach.**
2. **LCA impact categories show a slower increase** for the recycled product scenario.
3. **Littering often is the most common EoL fate** and is often overseen in assessments.
4. Increasing rate of plastics production comes with an increasing rate of littering.
5. The most effective way to **reduce overall littering of plastics is EoL alternatives to landfill**.
6. **Unwanted substances** in plastic products **will continue to be in the use phase if we recycle** products.

[1] Stella Architect software https://www.iseesystems.com/store/products/stella-architect.aspx [2] Plastics production: Geyer et al. (2017); OECD (2022) – with major processing by Our World in Data. "Annual plastic production between 1950 and 2019" [dataset]. Geyer et al., "Production, use, and fate of all plastics ever made: https://ourworldindata.org/grapher/global-plastic-production-projections [3] PLEX database: https://nexus.openlca.org/database/PLEX

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