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Circular Plastics Modelling - A Cooperation between PBL and TNO

Via the knowledge programme “monitoring and steering the circular economy (MSCE)”, PBL and TNO have jointly collaborated on modelling the economic and environmental impacts of a circular plastics sector (see Figure 1). The 2024 project focused on preparing the practical links between an economic model and models for assessing material flows and their impact, using plastic packaging as a case study.

Model framework overview

The first link consisted of (1) getting a consistent dataset on monetary and physical values for plastic production sectors and the second link (2) likewise for the plastic waste treatment sector. The latter includes cost data for a scenario reflecting the current plastic packaging waste treatment system, and a scenario for advanced waste treatment, including chemical recycling technologies.

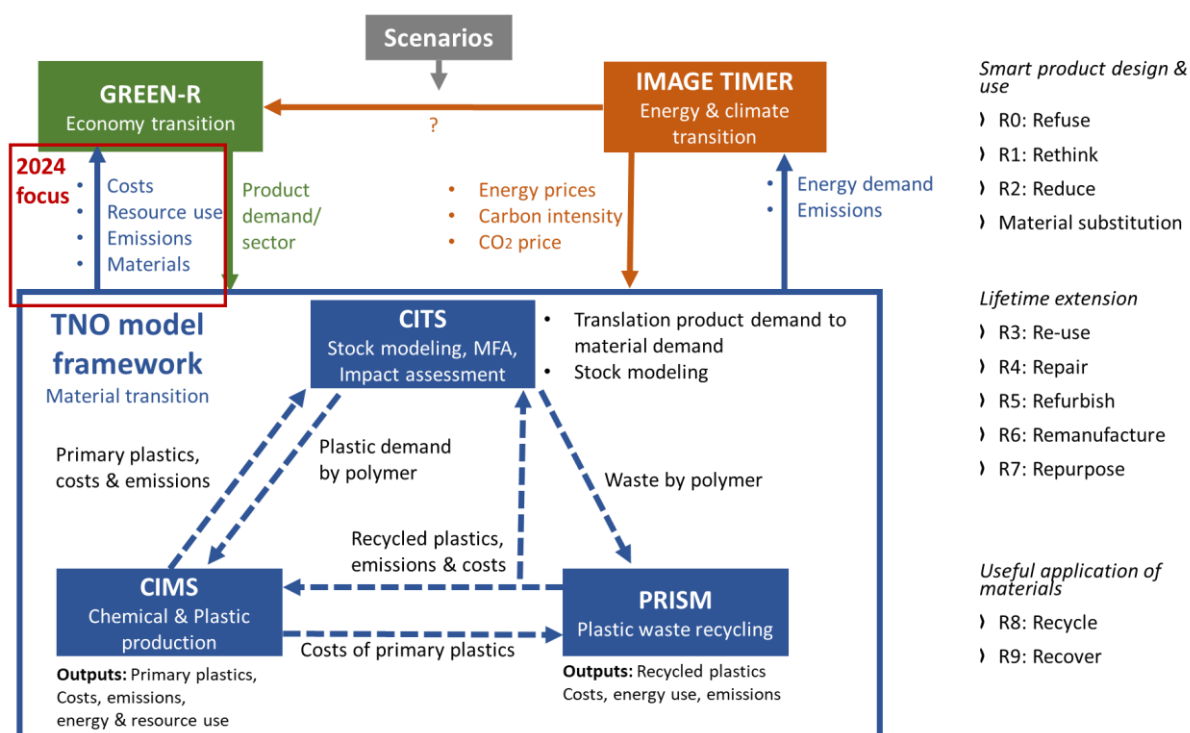


Figure 1: Model Framework as conceptualized in 2022¹. This year's project focused on providing plastic and waste treatment data to GREEN-R.

Economic and physical data integration

To link the economic flows (in Euro) of the PBL model (GREEN-R) to the physical flows (in tonnes) of the **TNO models (CITS & PRISM)**², these values were translated. We followed the approach by

¹ Van Harmelen et al, 2022, Design of a TNO-PBL model network on plastics circularity

² More information on the [Circular Industrial Transformation System \(CITS\) model](#) and the Plastic Recycling Impact Scenario Model (PRISM) can be found [here](#)

Gerlagh & Lorang (2024)³ for integrating material flows into a Computable General Equilibrium (CGE) model. In this process, Social Accounting Matrix (SAM) from CGE models is complemented with Physical Input-Output Tables (PIOTs) for the tracked materials. The SAM includes data on economic transactions within an economic system. Similarly, the PIOT shows the physical flows of goods in an economic system. The idea is to match the economic transactions with data on physical flows.

In the Prodcom database by Eurostat, both monetary and physical data is reported per ISIC code (International Standard Industrial Classification). This is a classification standard in global trade, which can be translated to the data classification applied in the database of the [Global Trade Analysis Project \(GTAP\)](#), which forms the basis for the GREEN-R model. This data was used to calculate the plastic (packaging) material intensity (tonnes per euro) to translate economic flows to material flows. To identify plastic (packaging) within those flows, data of Drewniok et al 2023⁴ was applied. However, when comparing the results with other references, major differences are visible. An initial analysis of the Eurostat data revealed several data issues that require a deeper analysis and data balancing for creating more reliable material intensities. However, this was beyond the scope of this project.

Plastic waste data analysis

In addition to the production and use, also data on physical plastic (packaging) waste volumes were prepared for integration into GREEN-R. For that, three different Eurostat databases on waste generation, waste treatment and plastic packaging were analysed. However, that data was proven to be inconsistent, probably because of reporting issues. Moreover, the total plastic waste quantities amount to just around half of the numbers reported by Plastics Europe. Hence, the use of alternative sources was suggested, such as data from PlasticsEurope. To increase the plastic data consistency in the model, it is suggested to also explore the method of dynamic stock modelling. In a next phase, this will be implemented in the GREEN-R model to calculate internally consistent amounts of plastic production, stocks, and waste generation.

Integrating plastic waste treatment

Furthermore, the integration of plastic waste treatment to GREEN-R was prepared by developing variable cost functions based on TNO's model data on recycling technologies. These technologies include four chemical recycling technologies next to conventional mechanical recycling and energy recovery.

Using scenarios of Stegmann et al. (2024)⁵, these technologies were combined into a scenario reflecting the current plastic packaging waste treatment system, and a scenario for advanced waste treatment. By integrating recycling cost factors such as energy use and labour, GREEN-R can endogenously calculate the costs of producing low-quality and high-quality plastic recyclates, as well as chemical intermediates from pyrolysis & gasification.

Quality restrictions in recycling

Due to impurities of mixed waste streams and quality losses during use and recycling, mechanically recycled plastics do not achieve the same level of quality as virgin plastics. This limits their

³ [Gerlagh & Lorang, 2024, Material Source and Waste Taxes in Competitive Equilibrium](#)

⁴ [Drewniok et al, 2023, What to Do about Plastics? Lessons from a Study of United Kingdom Plastics Flows](#)

⁵ [Stegmann et al., 2024, Circularity and greenhouse gas assessment of the plastic packaging and beverage carton system in the Netherlands until 2050](#)

applicability in products with high-quality requirements. To ensure that the lower-quality recycling outputs are not allocated to unsuitable product applications, a first assessment on quality restrictions for certain economic sectors was conducted.

Conclusion and next steps

In conclusion, our work provided the fundament for a combined model run of GREEN-R and the TNO models (CITS and PRISM). The next steps towards such a model run involve (1) addressing the data challenges identified in this project to achieve more reliable results and (2) integrating the improved data and cost function into the models.

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