Plastic recycling in a circular economy; determining environmental performance through an LCA matrix model approach.

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In a circular economy, renewability for plastic polymers is required in order to reduce pressure and negative impacts on the environment. Therefore, an outlook on the environmental impacts of different recycling methods is crucial, especially for determining the optimal recycling choice for products made from plastic polymers. In order to give this outlook, the environmental performance of 10 different recycling technologies with varying technology readiness levels (TRLs) was assessed, using the chemical properties of the top 25 produced polymers in Europe. The results of this analysis were collected in a life cycle assessment (LCA) ‘matrix’ model. The LCA matrix model will give insights in optimal recycling pathways from an environmental perspective. To also simulate realistic plastic recycling challenges, case studies were developed, of which the first one includes PE/PP foils from municipal waste and the second case ABS plastic with brominated flame retardants. These case studies are to be used as an addition to the LCA matrix model results. Furthermore, the potential emission reduction was assessed by combining the optimal LCA matrix outcomes with European polymer demand data. The LCA matrix model illustrates that potential environmental performance of recycling technologies varied strongly per polymer type and did not always follow the state-of-the-art recycling hierarchy. Commodity plastics performed well with various tertiary recycling technologies, such as gasification and pyrolysis to monomers; secondary mechanical recycling was environmentally outperformed. A focus on material preservation through primary recycling is environmentally beneficial for most engineering and high performance plastics. To enhance the performance of primary recycling technologies, a higher purity of plastic waste is required, to be obtained through improved sorting. As demonstrated in the case studies, low sorting efficiencies due to impurities increases environmental impacts, as significant quantities are sorted out and incinerated. Hence, optimal environmental performance of recycling is obtained where pre-treatment (sorting, cleaning) is adapted to the recycling technology. According to the model, recycling the 15 most demanded polymers in Europe reduces CO_2 emissions from plastics by 73% or 200 Mtonne CO_2-eq. Though using this optimal environmental perspective for recycling of plastic polymers, improved choices can be made for different plastic polymers.

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