Pathways to sustainable plastics – *A comparative analysis of bio- and CO2- based feedstocks for virgin sustainable plastics production in function of application*

Plastics are likely to remain a globally omnipresent material. In a circular sustainable future, plastics are produced based on renewable carbon feedstocks (recycled, biomass, and CO_2) – thereby changing the global plastic value chains. To understand the full potential of biobased plastics, we need to look at the entire future plastics system and compare biobased feedstock to other renewable options. As recycled plastic feedstock is nearly always economically and environmentally superior over alternative renewable carbon sources, this pathway will need to be maximized. However, even with global recycling rates achieving their theoretical potential, only around 60-70% of current volumes can be expected to be produced based on recycled feedstock considering losses in production, use, and recycling. Thus, significant virgin plastics production would still be required to replace losses and cover plastics demand growth, with biomass- and CO2- based plastics as the only remaining options to do this sustainably. Thus, we define three pathways for virgin sustainable plastics production in the future (1. Novel biobased, 2. Drop-in biobased, and 3. CO2-based), these pathways need to be compared to find an optimum in terms of sustainability and economic feasibility.

Expected results of our work are a comparative analysis in terms of sustainability (LCA) and economic feasibility for the three different pathways for production of each of the 9 current major plastics materials, covering 90% of today's global plastic volume. Rather than concluding a general % that will be biobased vs alternative feedstocks, the best choice of pathway directly relates to the function a plastic material fulfills in society. The comparative analysis across pathways allows us to, for the first time, set a vision for which production pathway is most optimal to be used for which function, application, and plastic material. In our presentation we will discuss not only these results, but also translate these into a global merit order for renewable carbon feedstock allocation across plastic material types and functions. Furthermore, we can synthesize what the plastics system of the future could look like, including the role of biobased plastics. Finally, we will address considerations around recyclability of novel biobased materials, biodegradability, and complexity in the future plastics system and outline implications, requirements, and actions needed to move towards this future.