The textile industry sector is one of the largest in the world, with a current estimated global market value of $ 1 trillion USD. A significant issue in this sector is its detrimental environmental impact throughout its life cycle, including production, use, and disposal. Recent research indicates that the textile industry accounts for approximately 5% of the total global waste, generating between 65 and 92 million tons of textile waste annually. It also contributes to 10% of global carbon emissions and 20% of the world's wastewater, with projections suggesting a continued increase in these figures. Polyethylene terephthalate (PET) is one of the most widely used polymers in textile production. However, recovering this polymer and other components from mixed textile waste via traditional methods, such as mechanical recycling, is a challenging task. As a result, most textile waste typically ends up being incinerated, landfilled, or in the environment.

Methanolysis, a novel chemical recycling method, offers a promising alternative for valorizing mixed textile waste. This approach enables the depolymerization of certain plastics, such as PET, into its constituent monomers, which can be directly used for several applications or polymerized back into PET. Four variants of the methanolysis process have been reported: low-temperature, subcritical, supercritical, and vapor-phase methanolysis. A long residence time and unfavorable reaction conditions result in low-temperature and supercritical methanolysis being less desirable. Therefore, in this work, we present a computational framework that integrates process modeling and design with life cycle assessment to quantify the environmental benefits of depolymerizing PET mixed textile waste into dimethyl terephthalate (DMT) and ethylene glycol (EG) through the subcritical and vapor-phase variants of the methanolysis process. We compare our results with the environmental impacts of producing the EG and DMT monomers from fossil sources. Our analysis highlights critical components of the methanolysis processes with the highest environmental burdens. Our study provides valuable insights into the valorization of textile waste through methanolysis processes.