UNIVERSITY OF DELAWARE

CHEMICAL & BIOMOLECULAR ENGINEERING

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MODELING AND OPTIMIZATION FORMULATIONS FOR THE ANALYSIS AND DESIGN OF CIRCULAR ECONOMY NETWORKS

Ana Inés Torres is an associate professor in the Department of Chemical Engineering at Carnegie Mellon University. Her research lies in the general area of process systems engineering and focuses on sustainability. Current activities are in two broad areas: (i) the decarbonization of the chemical industry, with an emphasis on electrification and utilization of biomass for fuels and chemicals, and (ii) the recovery and reuse of materials, with an emphasis on the development of theories for the analysis of circular economy initiatives.

Dr. Torres earned her B.S. in Chemistry in 2003 and a diploma in Chemical Engineering in 2005, both from the Universidad de la República Oriental del Uruguay. After a number of years of industrial experience, she moved to the USA to pursue a Ph.D. in Chemical Engineering (University of Minnesota - Twin Cities). She completed her postdoctoral studies at the Massachusetts Institute of Technology (MIT). Most recently, Dr. Torres served as faculty in the Department of Chemical Engineering at the Universidad de la República, Montevideo, in Uruguay.

Dr. Torres is the recipient of the NSF CAREER award (2024), a consultant for UNIDO, and an associate editor of Clean Technologies and Environmental Policy. In 2025, she was named the CMU College of Engineering Dean's Early Career Fellow.

The current extract-make-use-dispose paradigm throughout product supply chains has enormous environmental and socioeconomic impacts, including climate change, biodiversity loss, depletion of natural resources, and pollution. Policymakers and industry practitioners have suggested the Circular Economy (CE) to solve these challenges. CE aims to re-design current processing/ consumption practices to eliminate waste and pollution, circulate products and materials at their highest value, and regenerate nature. Although conceptually simple, the development of CE networks is hindered by the lack of scientific guidance on how to implement and evaluate the effectiveness of CE initiatives.

This talk will present the results of recent projects related to the advancement of our understanding of CE networks. During the first part of the talk, I will discuss a generalized superstructure-based optimization framework for designing and optimizing circular economy (CE) networks under multi-criteria decision-making. We apply the proposed framework to a case study of the polyethylene terephthalate (PET) supply chain, considering various waste valorization pathways.

In the second part of the talk, I will present the advances on the dynamic modeling of CE networks. Dynamic modeling is needed as some CE initiatives, such as product reuse, evolve over time, so steady-state models are unsuitable. We start by proposing a dynamic model for a generalized actor, then derive specific models for five actors (a manufacturer, consumer, material recovery facility (MRF), recycling facility, and the Earth), and combine them to form a prototypical circular SC network. We apply this framework to the supply chain for plastic packaging to assess the effects of slowdown-the-loop initiatives, such as product reuse, and close-the-loop initiatives, such as increased recycling.