Circular Economy Systems Engineering: A Case Study on the Coffee Supply Chain

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The rising populations, the continuous effort for improvement in the standards of living, and the economic advancement under the current models of production and manufacturing lead to the depletion of natural resources and environmental degradation. Circular Economy (CE) appears as one of the most promising ways to reduce these impacts by looking beyond the current linear take-make-dispose models [1]. CE aims to solve resource, waste, and emission challenges confronting society by creating a production-to-consumption total supply chain that is restorative, regenerative, and environmentally benign. This transition is not trivial since it requires a holistic approach to quantitatively consider the multi-scale, multi-faceted and interconnected CE supply chains, identify opportunities for beneficial improvement, systematically explore interactions and trade-offs as well as assist the quantitative assessment and decision making [2].

Process Systems Engineering (PSE) could play a pivotal role towards this transition. As such, we present our novel framework along with an indicative case study [3]. First, we introduce CE assessment metrics for evaluating different aspects of CE at various levels. This is vital for effective decision making, and benchmarking, but it needs to be conducted holistically. Having established the key assessment metrics, then superstructure optimization is used to holistically evaluate alternative pathways for the transition from a linear to a circular economy. A techno-economic feasibility analysis of these pathways at a large scale through modeling and optimization will be also presented. Finally, a superstructure representation of the supply chain of coffee is presented, that involves alternative pathways for coffee harvesting and processing, waste utilization, product distribution and new/alternative products introduction. This analysis, in conjunction with feedback from experimentalists lead to the identification of the optimum CE supply chain for coffee.

References:

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