

Optimizing Industrial Operations: Balancing Economic and Environmental KPIs for a Circular Economy

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Primary topic: Method and Metrics

Secondary topic: Building a Sustainable Circular Economy for Materials & Products

Abstract:

To transition to a circular economy, businesses require a holistic understanding and optimization of economic and environmental key performance indicators (KPIs) across their value chain. From industry practitioners we learned that operational decisions today are typically optimized for economic benefits (revenue, profit, cost reduction), whereas environmental considerations are an afterthought, to comply with regulations, or to show progress towards high level corporate targets (such as achieving carbon neutrality by 2050).

Switching to more sustainable operations (e.g., using renewable energy or recycled inputs) is perceived to incur a cost, and assessing the tradeoffs between the environmental benefit and impact on economic performance is challenging. Business decision makers require a clear understanding of such tradeoffs. For example, an OEM was considering switching from natural gas ovens to electric ovens but needed a quantitative assessment of the environmental value versus capital and operating expenses. As another example, a consumer goods company was considering switching from their current process utilizing virgin materials to one using recycled feedstocks and needed to weigh the environmental benefit against the financial implications, such as costs and impact on revenue and profits.

We are working on a novel systems approach to comprehensively measure and integrate these often-conflicting KPIs, enabling businesses to make informed decisions that drive both profitability and sustainability.

Our approach consists of: (a) defining and measuring a set of economic KPIs (including costs and profits) and environmental KPIs (going beyond traditional energy consumption and GHG emissions to include resource usage and waste) relevant for industrial operations in a circular economy; (b) developing a utility function to capture the interdependencies between these KPIs; (c) using the utility function to jointly optimize these KPIs to maximize profitability and sustainability. We consider KPIs that span the entire value chain, from raw material procurement to production and sales to product use, end-of-life, and recovery. We describe a system to connect the stakeholders in the industrial value-chain, enable collection of data, and compute and optimize the KPIs.

To illustrate our approach, we present a case study from the industrial process manufacturing sector. We develop optimized digital sales and operations plans that minimize environmental impact while maximizing economic performance. This is achieved through simulation and joint optimization of relevant KPIs, such as greenhouse gas emissions, energy consumption, water consumption, recovered material use, production costs, and revenue. The optimization space covers multiple scenarios for example, different mix of virgin and recovered materials, production processes, energy sources, consumption of resources, and generation of waste and effluents.