Chemical Engineering Master's Defense

ROLE OF UNCERTAINTY IN STREAMLINED LIFE CYCLE ASSESSMENT
Exploring the Case of Petrochemical Refineries and Polymer Manufacturing Units

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abstract

Life Cycle Assessment (LCA) is used in the chemical process sector to compare the environmental merits of different product or process alternatives. One of the tasks that involves much time and cost in LCA studies is the specification of the exact materials and processes modeled which has limited its widespread application. To overcome this, researchers have recently created probabilistic underspecification as an LCA streamlining method, which uses a structured data classification system to enable an LCA modeler to specify materials and processes in a less precise manner. This study presents a statistical procedure to understand when streamlined LCA methods can be used, and what their impact on overall model uncertainty is. Petrochemicals and polymer product systems were chosen to examine the impacts of underspecification and mis-specification applied to LCA modeling. Ecoinvent database, extracted using GaBi software, was used for data pertaining to generic crude oil refining and polymer manufacturing modules. By assessing the variation in LCA results arising out of streamlined materials classification, the developed statistics estimate the amount of overall error incurred by underspecifying and mis-specifying material impact data in streamlined LCA. To test the impact of underspecification and mis-specification at the level of a product footprint, case studies of HDPE containers and aerosol air fresheners were conducted. Results indicate that the variation in LCA results decreases as the specificity of materials increases. For the product systems examined, results show that most of the variability in impact assessment is due to the differences in the regions from which the environmental impact datasets were collected; the lower levels of categorization of materials have relatively smaller influence on the variance. Analyses further signify that only certain environmental impact categories viz. global warming potential, freshwater eutrophication, freshwater ecotoxicity, human toxicity and terrestrial ecotoxicity are affected by geographic variations. Outcomes for the case studies point out that the error in the estimation of global warming potential increases as the specificity of a component of the product decreases. Fossil depletion impact estimates remain relatively robust to underspecification. Further, the results of LCA are much more sensitive to underspecification of materials and processes than mis-specification

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