

Economic Input-Output-Based Life-Cycle Assessment (EIO-LCA)

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Introduction:

Effective environmental decision making requires information on the consequences of alternative designs. To make informed choices, businesses, consumers and regulators must know the environmental consequences of available materials, designs, manufacturing processes, product use patterns and disposal. Life-cycle assessment (LCA) is a systematic tool to provide this information. LCA attempts to trace out the major stages and processes involved over the entire life cycle of a product from raw material extraction to ultimate disposal, quantifying environmental burdens at each stage.

Problem Statement:

Current LCA methods as recommended by the Society of Environmental Toxicology and Chemistry (SETAC) and the U.S. Environmental Protection Agency (EPA) are subject to several major limitations. One of the most serious difficulties is the choice of an appropriate problem boundary, considering that each industry is dependent, directly or indirectly, on all other industries. For example, cars are made from steel, which is made from coal and iron ore, which need automobiles for transportation and so on. Similar analysis is needed for every input into car making. Hence it is impossible to trace out all the direct and indirect interactions and the environmental burdens. The standard recommendation of SETAC/EPA LCA is to focus only on the most important process materials. However, such a narrow focus may ignore important effects and lead to incorrect decisions.

Approach:

Input-output analysis, developed by Wassily Leontief (for which he received a Nobel Prize in 1973), is a technique for capturing all the economy-wide interdependencies. It has been extensively used for planning throughout the world. It is used to estimate additional production required in all the sectors of the economy to support increases in output of any given sector.

Our economic input-output analysis-based life-cycle analysis (EIO-LCA) method involves augmenting conventional economic input-output tables with appropriate sectoral environmental impact indices which can then be used to analyze economy-wide environmental impacts of changes in the output of selected industrial sectors. We employ the most detailed (485 sectors) and the most recent (1992) input-output tables for the U. S. and augment them with various sectoral environmental effect vectors. The environmental effects estimated include:

Resource inputs:

- Electricity consumption
- Fuel use
- Ore consumption
- Fertilizer use
- Water consumption

Environmental outputs:

- Toxic emissions from the Toxics Release Inventory (TRI)
- Toxicity-weighted chemical emissions (CMU-ET)
- RCRA hazardous waste generation and management
- Ozone depletion potential
- Global warming potential
- Conventional pollutant emissions

We also estimate the social costs of pollution.

Product EIO-LCA:

EIO-LCA using only the published input-output tables has the advantage of tracing out full direct and indirect environmental impacts of outputs of industry sectors. However, it suffers from limitations of high levels of aggregation. We have developed several models for extending the EIO-LCA methodology to conduct LCAs of individual products or processes which involve selective disaggregation of existing industry sectors, and/or hypothetical creation of new industry sectors.

Hybrid LCA Models:

In cooperation with IKP from the University of Stuttgart, we are developing hybrid LCA models that eliminate the limitations of using the process analysis-based LCA and the EIO-LCA separately. The hybrid models provide desired detail and economy-wide coverage while giving comprehensive LCA answers.

EIO-LCA Software:

We have created a software to perform life-cycle assessment using economic input-output techniques. The program has a user-friendly interface and allows the user to run life cycle assessment scenarios in a time-effective manner.

Platform: Windows 95 or Windows NT

Available: through the Green Design Initiative

WWW version: www.eiolca.net

Representative Publications:

-“Use of Economic Input-Output Models for Environmental Life Cycle Assessment,” C. Hendrickson, A. Horvath, S. Joshi and L. B. Lave, *Environmental Science & Technology*, April 1998.

-“Comprehensive Product Life Cycle Assessment Using Input-Output Techniques,” Satish Joshi, unpublished Ph.D. thesis, Carnegie Mellon University, May 1998.

-“A Comparison of the Environmental Implications of Asphalt and Steel-Reinforced Concrete Pavements,” A. Horvath and C. Hendrickson, Transportation Research Board Conference, Washington, DC, January 1998, and Transportation Research Record, 1998.

-“Comparing Two Life Cycle Assessment Approaches: A Process Model- vs. Economic Input-Output-Based Approach,” C. Hendrickson, A. Horvath, S. Joshi, M. Klausner, L. B. Lave and F. C. McMichael, IEEE International Symposium on Electronics and the Environment, San Francisco, CA, May 1997.

-“Using Input-Output Analysis to Estimate Economy-Wide Discharges,” L. Lave, E. Cobas, C. Hendrickson and F. McMichael, *Environmental Sci. & Technology*, 9/1995.

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