Environmental Life Cycle Cost Analysis of Products

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Objective of LCECA tool

- The objective of this proposed LCECA model is to include eco-costs into the total cost of the products. Eco-costs are both the direct and indirect costs of the environmental impacts caused by the product in its entire life cycle.

LCCA Background

- The application of LCC methods during product and system design and development is realized through the accomplishment of Life Cycle Cost Analysis (LCCA).

- LCCA may be defined as a systematic analytical process for evaluating various designs or alternative courses of actions with the objective of choosing the best way to employ scarce resources.

- The ultimate objective of the LCCA of any product is to provide a framework for finding the total cost of design/development, production, use and disposal of the product with an intention of reducing the total cost.

Review of LCCA Methodologies

- This methodological review includes some of the specific cost models on the basis of their frameworks, methodology and limitations.
- An attempt has been made to evolve a generic understanding of several prominent life-cycle cost models.
- This review is presented in two stages. In the first stage of the review, the methodologies of the existing models are analysed. Secondly, elemental features of each model are compared.

Continuation

Reviewed models are:

- LCCA model of Fabrycky & Blanchard
- LCCA model of Woodward
- LCCA model of Labor factor
- Activity Based Costing (ABC) model
- Economic Input-Output (EIO) LCA model
- Design to Cost (DoC) Model
- PLCCA to Manufacturing System
- Total Cost Assessment (TCA) Model

Development of LCECA model

- The objective of this proposed LCECA model is to include eco-costs into the total cost of the products. Eco-costs are both the direct and indirect costs of the environmental impacts caused by the product in its entire life cycle.

- Subsequently, this LCECA model identifies the feasible alternatives for a cost effective, eco-friendly design of parts/products.

- Ultimately, it aims to reduce the total cost with the help of green or eco-friendly alternatives in all the stages of the life cycle of any product.

Significance of LCECA

- Development of Efficient environmental management systems including hidden and unaccounted environmental costs
- To make companies to realize and recognize the initiatives such as proper materials and waste management, efficient process & product design, energy efficiency, and recycling can be both profitable and environmentally preferable
- To satisfy the international standards like ISO 14000 and other Eco labels

- To make potential product substitutions anywhere in the product life cycle

Significance of LCECA(2)

- To understand, through Life Cycle Environmental Cost Analysis, the true costing and pricing of eco-friendly products.
- LCECA addresses both direct and indirect environmental costs, as well as explores the avenues for cost reduction or even revenue generation through “Reuse/Recycle” and renewable energy strategies.

Significance of LCECA(3)

- To provide a practical tool for assessing alternative product designs on the basis of both cost and environmental-friendliness
- To provide inputs for competitive Environmental Marketing such as eco-labelling,green manufacturing and sustainable development

Eco-costs of LCECA

- costs of the effluent control,
- costs of the effluent treatment,
- costs of the effluent disposal
- cost of implementation of Environmental Management Systems
- costs of Eco-Taxes
- costs of rehabilitation
- costs of energy
- cost savings of recycling and reuse

CBS of Eco-costs(1)

- C_1 = **cost of the effluent control**
  = $C_{11} + C_{12} + C_{13}$**, where**
- C_{11} = **cost of the effluent control system implementation**
- C_{12} = **cost of the effluent control system operation**
- C_{13} = **cost of the effluent control system maintenance**

- C_2 = **cost of the effluent treatment**
  = $C_{21} + C_{22} + C_{23}$**, where**
- C_{21} = **cost of the effluent treatment system implementation**
- C_{22} = **cost of the effluent treatment system operation**
- C_{23} = **cost of the effluent treatment system maintenance**

CBS of Eco-costs(2)

- C_3 = **cost of the effluent disposal**
  = $C_{31} + C_{32} + C_{33}$, where
- C_{31} = **cost of the effluent collection**
- C_{32} = **cost of the effluent transportation**
- C_{33} = **cost of the effluent land fill or incineration**

- C_4 = **cost of environmental management systems**
  = $C_{41} + C_{42} + C_{43} + C_{44}$, where
- C_{41} = **cost of implementation of environmental management systems**
- C_{42} = **cost of operation of environmental management systems**
- C_{43} = **cost of maintenance of environmental management systems**
- C_{44} = **cost of certification for environmental management systems**

CBS Eco-costs(3)

- C_5 = **cost of the eco-penalties***

- C_6 = **cost of rehabilitation**
  = $C_{61} + C_{62}$ **, where**
- C_{61} = **cost of all damages like health disorders, accidents**
- C_{62} = **cost of production losses caused by the damages**

- C_7 = **cost of energy**
  = ΣC_i **where i = 1 to n (number of energy systems)**

*** eco- penalties include country or product specific eco-taxes, levy etc.**

CBS Eco-costs(4)

- C_8 **= cost savings of reuse and recycling**
  = $C_{81} - (C_{82} + C_{83})$, **where**
- C_{81} = **cost of implementation of** R^2 **strategies**
- C_{82} = **cost of savings of reuse strategies**
- C_{82} = **cost of savings of recycling strategies**
- T_c **= total cost of the product or part**
- $T_c = a + b_1C_1 + b_2C_2 + \ldots + b_8C_8$

The mathematical model

This mathematical model aims to define the relationships between the total cost of products and the various eco-rehabilitation costs concerned with the life cycle of the products, and determine quantitative expressions between the above said costs.

***The basic assumptions are*:**

1. The regression equation was assumed to be linear
2. Two types of variables - one dependent total cost and the other independent eco-rehabilitation costs.
3. Data used for the regression and correlation analysis should be considered sample data.
4. Determination of the regression equation has been done by least-squares method, based on these assumptions.

Methodology of LCECA application

- LCECA can be applied at any stage or stages of the life cycle of a product, by suitably defining the system boundaries.

- Streamlining LCA methods requires that the researcher make difficult choices as to what to include and what to omit from a study. These choices can relate to the level of specificity, the study's boundaries and other conditions. These choices must be made within certain limits.

Streamlined LCA

Background

LCAs may have to be streamlined to focus on a few critical dimensions of a product's environmental impact, rather than all dimensions

Streamlined LCA

Methods

- limiting or eliminating life cycle stages,
- focusing on specific environmental impacts or issues,
- eliminating specific inventory parameters,
- limiting or eliminating impact assessment,
- using qualitative as well quantitative data,
- using surrogate data,
- establishing criteria to be used as show stoppers or knockouts,
- limiting the constituents studied to those meeting a threshold quantity, and
- combining streamlining approaches.

Issues of Streamlined LCA

- How will the study be used?
- What alternatives will be considered as a result of the study?
- What information is needed to support the use of the study?
- What level of specificity is required?
- What data quality objectives must be met?
- How much is already known?
- How well-defined and specific is the product under the study?

LCA-LCECA Interface

- LCA study of a high pressure cleaner has been used as a validation case study.
- Only the “Manufacturing” life cycle stage has been taken for the LCECA study.
- Data source types include measurements, computations,extrapolations and estimates.
- Only the environmental burdens of this product and the influence of their costs on the total cost are analysed.

Results & Discussions

- **Outputs of the existing LCA study of high pressure cleaners are used.**
- **Only cumulative costs of all the eight eco-cost categories are applied.**
- **Impacts pertaining to the manufacturing phase are only analysed.**
- **The cost values used are relative in nature.**

Results & Discussions(2)

- **Cumulative impact indices are multiplied with the respective costs to get the eight eco-costs.**
- **Equations of the multi-variate regression model are solved by minitab software for the time-being**
- **LIMDEP 7 is the computational software to be used for validating sub-sequent case studies on LCECA.**

Results & Discussions (3)

- **Relationships between the total cost of the product and all eight eco-costs are found.**
- **Significance of each category of the eco-cost has been understood.**
- **Same kind of relationships can be found with suitable alternatives so that comparison can be made.**
- **Probable alternates are suitably combined to provide less eco-cost and more eco-friendly product.**

Future Directions

- **Accomplishment of Break-Even Analysis**
- **Inclusion of Sensitivity Analysis**
- **Addition of Risk/Uncertainty Analysis**
- **Validation of LCECA through variety of case studies**
- **Development of Compatibility of LCECA with LCA**