Transactions of the Materials Research Society of Japan 25 [2] 609-612 (2000)

Keynote Lecture

Current Status and Future directions of LCA as a technique of environmental assessment of products

Norihiro Itsubo
Japan Environmental Management Association for Industry
Ueno 1-17-6, Taitoh-ku, Tokyo, Japan 110-8535
Fax: 81-3-3832-0515, e-mail: itsubo@jemai.or.jp

Abstract
The interests for LCA (Life Cycle Assessment) have been increased rapidly by the consideration for protection of environment and standardization of ISO 14000 series. Framework of LCA procedure is almost determined by ISO 14040. The level of studies related with LCA has been advanced through a lot of researches by academic sectors and industries. However, there are a lot of problems in LCA that do not meet a consensus internationally. It takes much time to calculate inventory data due to the lack of information. Then the development of database providing inventory table has been required strongly. These data should keep reliability and precision to some degree. It is important to investigate how to assess the reliability in LCA. Impact assessment, especially, is now developing field. Several methodologies are proposed in Japan, but every method has weak points respectively. Weighting, one of the process of impact assessment, may involve subjective judgement unavoidably. This means that this process can not be accomplished from only natural science. Furthermore, the range of environmental problems is so wide. It is quite difficult to compare between the different environmental problems without fully discussion. In this paper, we introduced current status of LCA studies as well as future directions in Japan.
Key words: Life cycle assessment (LCA), Life cycle impact assessment (LCIA), weighting, Damage functions

1. Introduction

LCA has been expected to be a key methodology to develop environmental conscious products and realize sustainable development.

Today, a lot of case studies of LCA have been applied in Japan. Main ISO framework related with LCA (14040s) have almost been standardized. Furthermore, a lot of impact assessment methodologies have been proposed in internationally.

It takes a lot of time and cost to accomplish the full LCA, because we have to collect the basic factory data and the information of other sector. It is quite important how to reduce time for investigation effectively keeping the reliability of results.

However, ISO standardization does not describe the practical method and not provide database for application. Consequently, it is essential for us to construct the reliable inventory database, develop the LCA software and the impact assessment methodologies, and construct a network system.

The purpose of this paper is to provide the present situation and problems of Life cycle assessment including personal results.

2. Present Situations and Problems of LCA

According to ISO 14040 (*guide and framework*), general LCA procedure can be composed of 4 parts, goal and scope definition, Life cycle inventory analysis, Life cycle impact assessment and Life cycle interpretation (1). In fact, most of studies related with LCA are focused on the second step, inventory and the third step, impact assessment. We will describe the present activities concerning these steps in Japan.

2.1 Inventory Analysis

In past, most of the studies were related with simple products like package. Currently, the numbers of case studies concerning Life Cycle Inventory (LCI) has been increased rapidly. We can see the studies for advanced industrial products like car, office machine and buildings. Today, most of major companies consider the life cycle aspects and treat LCA. However, we can not conclude all of LCA practitioner can apply LCA easily, because it takes a lot of time to collect the basic data and develop the method for assessment.

Consequently the requirement for establishment of LCI database that keep reliability is very high. Recently, most of database in Japan are obtained by the result of Input - Output analysis based on industrial statistics. These are very useful for constructing database, but the precision of data is not enough, because these are not measured and calculated data but estimated data. National LCA Project of Japan supported by MITI/NEDO has been started with the aim of constructing the LCA database from last year, 1998. 23 industrial association from upstream to downstream has been participated in this project. Figure 1 shows the participating industrial associations in National LCA Project of Japan. The database will be provided by network system. Consequently, we can expect that it becomes easier to collect the background database with reliability (2).

As a result of increase of case studies, the application of the result of LCA into business have been considered in various fields like environmental reporting and eco-labelling. Canon has applied the result of LCA into type3 of eco-labelling in JEMAI program (3,4), and described them in their website. The component of JEMAI program shows LCI data on preselected environmental indices in accordance with a present format.

Now, a lot of major companies has started to show the result of LCA in environmental reporting. Toyota published the results of LCI for their products in environmental report (5). In this report, environmental consciousted car has been assessed comparing with public car and proved that life cycle CO_2 emission of hybrid car is smaller than public car.

2.2 Impact Assessment

Concerning impact assessment, a lot of activities have been conducted in SETAC-Europe. In Japan also, many studies have been performed in recent years. In this passage, we would like to focus on the introduction of the activities of Europe and Japan.

2.2.1 Activities of Europe

Most of researcher related with LCIA have been involved in SETAC-Europe. In this organization, there are impact assessment working group that lead initiative of LCIA from the beginning of LCA. This working group aims at proposal of available characterization factor of impact categories respectively and suggest criteria for weighting procedure as one of the step of LCIA. SETAC-Europe suggest the way of thinking LCIA shown in Figure 2. They proposed 4 areas of protection, human health, natural environment, man-made environment and natural resources (6). In this discussion, the main objective is to propose the characterization factor of impact category, they don't mind these indicator express the effect of midpoint like radiative forcing or endpoint like the damage of human health.

Concerning the weighting methodologies, assessment across the impact categories, new version of Eco-indicator'99 has been published (7). The methodology has been entirely revised to improve the quality and to spread the range of assessment. This involves fate model that enables to estimate the increase of concentration of compartment like air. This method includes land use and resources depletion as impact categories. Furthermore, damage categories (human health, ecological health and resources) that express the contents of natural environment has been proposed and being estimated the damages of these categories by the emission of environmental loading substances. Aggregation of these damages have been assessed by panel approach. They classified into 3 types of the way of thinking for environment and provide results of these types of single indicator respectively.

2.2.2 Activities in Japan

In Japan, several weighting methodologies have been proposed in recent years. Impact assessment committee, in National LCA Project of Japan, have compared these methodologies with case studies to characterize them. In this studies, we adopted a imaginary copy machine and compared the result (8). Figure 3 show the comparison of the result applied by weighting method proposed in Japan. This figure can be classified into the life cycle stages of imaginary copy machine. We can see from Figure 3 that they share certain similarities in that the stage of usage is

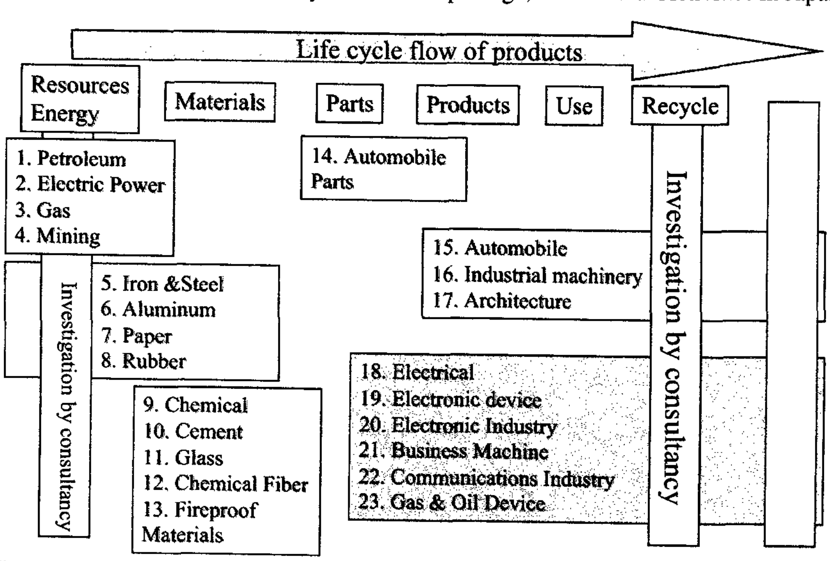

Fig. 1 Relationship between generic life cycle of products and participating industrial associations in National LCA Projects

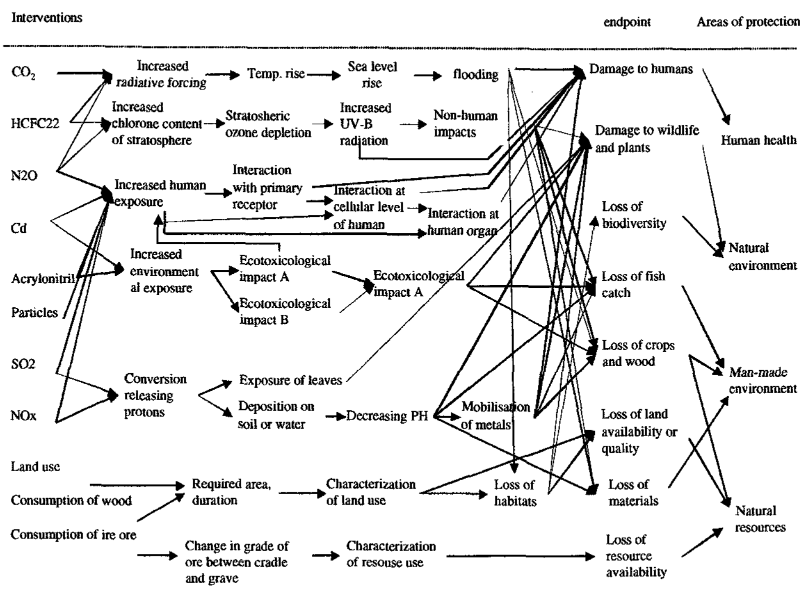

Figure 2 The conceptural figure of life cycle impact assessment in SETAC Europe (4)

dominant in life cycle of product. Figure 3, furthermore, shows that the stage of end of life is not serious. This is mainly due to the scenario of disposal of product. If we can include the inventory of after landfill or incineration into the boundary, the result may be changed. Figure 4 illustrates the comparison between 3 approaches classified into environmental substances. This figure shows that the contribution of substances are entirely dependent on methodologies. The result by Yasui showed that the effect of waste is dominant and account for more than 70%. According to Nagata's result, the substances that cause water contamination like BOD (biotic oxygen demands) and COD (chemical oxygen demands) occupied about 60%. The result of Itsubo's approach illustrates that the impacts by the consumption of lumber and that of natural gas, and the emission of CO_2 are estimated as dominant.

A comparison between weighting methodologies has been summarized in Table 1. They differ entirely from the considering safeguard subjects, considering impact categories and involving substances except for the calculated results are expressed as dimensionless. It is important to establish the criteria that can be available for LCA practitioner to choose the method.

To improve the reliability of impact assessment, it is essential to reflect the knowledge of natural scientists. This year, 1999, a committee that aim at establishment of damage function that relate emission with damage of category endpoint has been launched in National LCA Project of Japan.

3. Personal Studies related with LCA

In this paper, we show the result of impact assessment for commercial materials (steel, aluminum, copper, zinc) as a case study. The scope of this study is mining the energy resources, transportation overseas, the manufacturing. The stages of disposal and transportation in Japan are excluded. In the last report used the inventory data are calculated from the Japanese statistical tables and the assessment was restricted to several substances (9). In this paper, we used the inventory database to increase the numbers of substances involving within the methodology. Some of air pollution substances like CO_2, NOx and SOx, we adopted Japanese references, the rest of substances are obtained from IDEMAT, database in Netherlands. As a result, we can include more than 30 environmental loading substances for impact assessment. The details of the methodologies has been described in references (8, 9, 10).

The results of impact assessment has been summarized in Table 1. We can see that the contributions of impact categories are entirely dependent on metals. The total impact of steel is less than that of rare metal like copper and zinc. In steel making, the problems of toxicity substances, greenhouse effects, and energy resources depletions are comparatively serious. Especially, the impact of the emission of toxic substances like dioxins by the combustion of coal that contain chlorine is important (10). Concerning rare metals such as copper and zinc, the impact of mineral resource depletion is dominant, because of the lack of these reserves.

4. Conclusion

So far we have outlined the present situation and problems of LCA including personal results of case studies for metals. In the past year, we have felt keenly that the necessity of systematically developing inventory databases as a basis of LCA has been spread on the various fields. A lot of companies have started to apply LCA in business with eco-labelling and environmental reporting. National LCA Project of Japan that aimed at the construction of a database with the contributions by 23 industrial associations have been paid attention in international. Several weighting methodologies in LCIA have been proposed and introduced with a lot of case studies in recent years. In weighting procedure, it is impossible to avoid the subjective judgement because aggregating to single index will involve the comparison of safeguard subjects such as human health and ecological health. Firstly, it is important to distinguish between empirical analysis based on natural science and normative analysis based

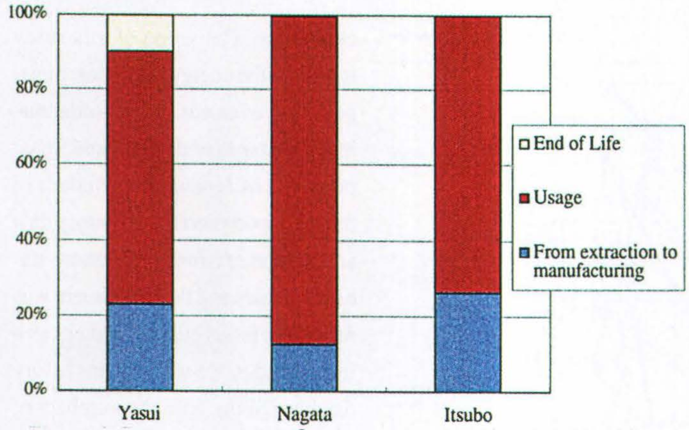

Figure 3 Comparison between the results classified into the life cycle stages (manufacuturing/assembly, usage and end of life) of weighting methodologies proposed in Japan. The results share the certin similarities.

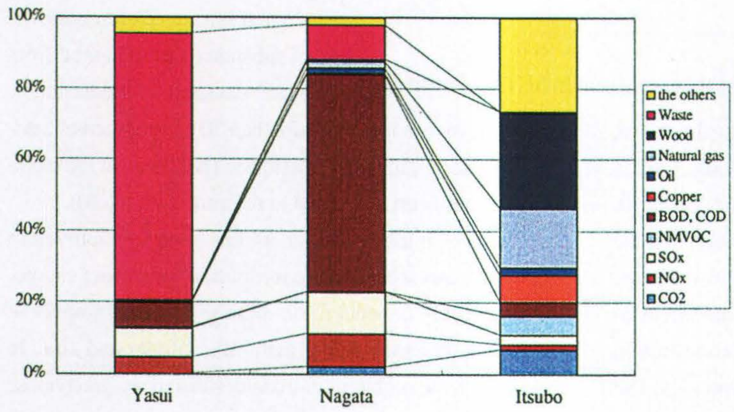

Figure 4 Comparison between the results classified into the substances of weighting methodologies proposed in Japan. The results are entirely depending on the methodologies.

on social science. Secondly it is essential to accumulate and reflect the knowledge of natural science. At the same time, we should develop the method such as monetization and panel approach that enable to relate the damage of endpoint with single index. It is hoped that these activities will be clue for the solution of problems mentioned above.

5. References

1) ISO 14040; life cycle assessment- guide and framework (1997)

2) Norihiro ITSUBO and Yoshifumi NAKAHARA; Current Status and Future Directions of the National LCA Project in Japan ECP News Letter 99-10, pp.1

3) Haruo UEHARA; JEMAI Program - Quantitative Environmental Information Labels, ECP News Letter 99-10, pp.13

4) Canon; Environmental report 1999

5) Toyota; Environmental report 1999

6) SETAC-Europe: Second Working Group on LCIA (WIA-2); Best Available Practice Regarding Impact Category Indicators in Life Cycle Impact Assessment, Int. J. LCA 4 (3) 167-174 (1999)

7) Pré; Eco-indicator'99, methodology report

8) Norihiro ITSUBO et al., submitting to Int. J. LCA

9) Norihiro ITSUBO and Ryoichi YAMAMOTO submitting to MRS-J

10) Norihiro ITSUBO; submitting to Int. J. LCA

Table 1 Summary of the weighting methodologies developed in Japan

	Steel		Aluminium		Copper		Zinc	
	value	composition	value	composition	value	composition	value	composition
Global Warming	4.07E-12	17.4	4.28E-11	10.5	2.62E-11	1.2	1.44E-11	2.0
Ozonelayer Depletion	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0	0.00E+00	0.0
Acidification	1.72E-12	7.4	2.47E-11	6.0	2.10E-10	9.4	1.33E-11	1.9
Toxicity Substances	6.08E-12	26.0	9.53E-13	0.2	4.74E-13	0.0	1.40E-12	0.2
Air Pollution	1.33E-12	5.7	1.93E-11	4.7	1.58E-10	7.1	1.08E-11	1.5
Water Pollution	4.05E-15	0.0	0.00E+00	0.0	0.00E+00	0.0	4.23E-15	0.0
Eutrophication	9.23E-16	0.0	8.24E-13	0.2	6.19E-16	0.0	3.87E-14	0.0
Photochemical Oxidant	3.04E-12	13.0	1.88E-11	4.6	1.56E-12	0.1	4.27E-12	0.6
Mineral Resource Depletion	2.89E-12	12.4	2.26E-10	55.2	1.80E-09	81.0	6.35E-10	89.6
Energy Resource Depletion	4.23E-12	18.1	7.58E-11	18.5	2.62E-11	1.2	2.96E-11	4.2
Total	2.34E-11		4.09E-10		2.23E-09		7.09E-10	

(Received December 16, 1999; accepted February 7, 2000)