Application of LCA to Difference of Environmental Load from Distribution and Sales Patterns: Case Study of Soft Drink in Container

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1. Introduction

LCA is a method for evaluating the environmental loads of a product or service throughout its life cycle, so the evaluation essentially includes transport of the raw materials, the final product and etc., and the sales process. However, exiting examples of LCA have mainly evaluated the final production and manufacture stages. There is concern over the increase in environmental load due to the frequent transport and 24-hour operation of convenience stores, and the use of passenger cars for shopping by customers at large-scale suburban shopping centers. LCA is effective as an evaluation method for analyzing the differences in environmental load emissions in the distribution and sales stages due to these different sales methods. However, the forms of distribution and sales are complex, and as a result data collection and analysis is difficult, so in the past there have been few examples of LCA in this field[1].

This study applies LCA to analyze the differences in forms of distribution and sales, for the case of cold soft drinks in containers. In this work the breakdown of the environmental load emissions in the distribution stage were analyzed in detail, and effective measures to reduce the environmental load were investigated, which has not been examined in past studies.

2. Application of the LCA method to this study

In this study, the LC-\( \text{CO}_2 \) (life cycle \( \text{CO}_2 \)) was estimated for cold soft drinks in 350ml aluminum cans (hereafter referred to as the product). The scope of the evaluation was set as the life cycle from mining the raw materials to disposal. However, the specific scope of analysis was the distribution, sales, and consumer actions including each of the stages of transport, handling, storage, and sales from shipment of the product until use by the consumer. Also, for the same product, even if the form of distribution and sales differed, the amount of raw materials used and the manufacturing process can be considered to be the same. The form of distribution was simplified as distribution center (hereafter referred to as D.C.) and retail store (large-scale retail store, convenience store, automatic vending machine, hereafter referred to as large store, convenience store, and vending machine respectively), and the consumer’s actions, and their differences were analyzed.

The scope of the study is described in Fig.1. The life cycle of soft drink in container

![Fig.1: The scope of this study](image-url)
material production and manufacture of the contents of the product as well as the fuel consumption of the return transport of the truck were not considered. The setting of each element of the distribution and sales stages, the use and consumption stages, and the scope of the evaluation are summarized in Table 1.

3. Estimation of LC-CO₂ according to each sales form

Comparing the estimated LC-CO₂ results for each sales form as shown in Fig.2, it can be seen that the results for vending machines and convenience stores are about the same, and the results for large stores are smaller by about 17%. The percentage of the LC-CO₂ due to the distribution stage is about 50% for all forms, so it can be seen that the distribution stage has a large effect on the LC-CO₂.

The breakdown of the CO₂ emissions in the distribution stage is shown in Fig.3. For vending machines, the share of cooling in the vending machine and sales is large, and for convenience stores the share of air conditioning, lighting, and refrigeration for stock control is large. For large stores, the percentage of the LC-CO₂ associated with storage in a refrigerator at home and the passenger car used by the consumer for shopping are significant. For convenience stores there is a concern over excessive environmental load emissions due to the 24-hour operation, but from the results of this study the LC-CO₂ for one product is about the same as for large stores and vending machines. However, if the product is refrigerated again after purchase at the convenience store, the emissions will be larger compared with the other sales form.
4. Investigation of measures for LC-CO₂ reduction by sensitivity analysis

4.1 Sensitivity analysis with refrigeration time

There was no big difference between the total quantity for convenience stores and vending machines, so an analysis was carried out to determine how the LC-CO₂ varied with refrigeration time for sales in large stores and vending machines. In this study it was assumed that for product sold in large stores, the product was subsequently refrigerated for a certain length of time in domestic refrigerators. The analysis results are shown in Fig. 4. For the same refrigeration time, the CO₂ in the distribution stage of vending machines was slightly smaller, so the LC-CO₂ for purchase from vending machines is smaller than the case where drinks are purchased in a large store and stored for a long time at home before consumption. Also, shortening the refrigeration time was an effective measure to reduce the emissions.

4.2 Frequent transport of small quantities for vending machines

To shorten the stock (refrigeration) time, normally small quantities are frequently transported. As described in sub-section 4.1, this has the effect of reducing CO₂ due to storage, but it is possible that the LC-CO₂ will increase due to the increase in number of transports. Therefore we investigated the appropriateness of small quantity frequent transport, focusing on sales from vending machines where the effect of storage is large. The object of evaluation was the storage time of the product within the vending machines and transport by 2t trucks. Assuming that the number of vending machines delivered to within the truck delivery area is the same, a sensitivity analysis was carried out by reducing the truck loading rate associated with shorter storage time and increasing the number of deliveries, as shown in Table 2.

The analysis results are shown in Fig. 5. For a storage time of six days, the CO₂ was reduced by approximately 10% compared with 10-day storage time with low frequency large quantity delivery. This was because although the CO₂ from the truck increased due to the increased delivery frequency, the reduction in CO₂ due to shortening the storage time was larger. However, if the storage time was two days, it was found that the CO₂ from truck delivery was predominant.

4.3 Shift of switching transport mode for shopping

In the breakdown of the LC-CO₂ of distribution stage for large store (Fig.3), the contribution from trip to the store for shopping by passenger car was about 20%. Therefore the amount of reduction was estimated for the case where the passenger car was switched to a bus, a 50cc scooter, or a 400cc bike. For the scooter and bike, the contribution of manufacturing and fuel consumption[15] was considered. For the bus the contribution of fuel consumption was considered, and divided among seven passengers. The round trip distance was assumed to be 20km.

Estimated results are shown in Fig. 6. The results show that it is possible to reduce the CO₂ associated with transport for shopping by about 80% by switching to other transport means, and it is possible to reduce the overall CO₂ in the distribution stage by about 15%. It is considered that promoting switching from passenger car to scooter or bus is effective for reducing CO₂.

5. Conclusion

LCA was conducted to analyze the differences in forms of distribution and sales, for the case of cold soft drinks in containers. Needless to say, the following results depend on limited data and abstract-assumptions, and it is...
desirable that their reliability is not necessarily enough. Percentage of distribution and sale stage in the total LC-CO\textsubscript{2} is approximately half with each sales form. Each distribution forms shows the following features:

1) Large-scale retail store: LC-CO\textsubscript{2} is smaller than other distribution forms. LC-CO\textsubscript{2} associated with storage in a refrigerator at home and the passenger car used by the consumer for shopping has large share. the LC-CO\textsubscript{2} for purchase from vending machines is smaller than the case where drinks are purchased in a large store and stored for a long time at home before consumption.

2) Convenience stores: The share of air conditioning, lighting, and refrigeration for stock control is over half.

3) Vending machine: Most LC-CO\textsubscript{2} is exhausted. On the condition that 10-day stock time, Vending machine exhausts most LC-CO\textsubscript{2}, mainly because of refrigeration which account for over half.

The analyses suggests following three major measures for reducing LC-CO\textsubscript{2}.

1) For a storage time of 6 days, the CO\textsubscript{2} is minimized.
2) it is possible to reduce the CO\textsubscript{2} associated with transport for shopping by switching to other transport means, for example bus, scooter or bicycle, and it is possible to reduce the overall CO\textsubscript{2} in the distribution stage by about 15%.
3) It has been shown that the contribution of cooling to the LC-CO\textsubscript{2} is large. In recent years the electricity consumption in retail locations and homes is tending to reduce as a result of improvements in the refrigeration, cooling, and air conditioning control systems in convenience stores, and cooling and heating systems in vending machines, as well as the energy efficiency of domestic refrigerators, and it is important to promote this trend.

This study shows difference among the distribution and sales forms influence LC-CO\textsubscript{2}. It is important to evaluate of that differences.

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7. References


