Evaluation of LIME3 utilization method in Sekisui Chemical Group ESG management

Report on Assessment of Plastic Molded Products

June 2019

Sekisui Chemical Co., Ltd.

1. General

1.1 Assessment implementors

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2. Goal of the study

2.1 Reasons for carrying out the study

Sekisui Chemical has promoted two initiatives using LIME2. One is to carry out an LCA evaluation for each product at the product planning and development stage for each theme, and has recommended its use as a tool for conducting environmental impact assessments at design review meetings for product planning and development. The other is to calculate the “return rate to natural capital” as an integrated index that can show the impact of corporate activities on the natural and social environments and use it as a KPI for the company. In 2014, the calculation result as the index was released. It was converted into a KPI in 2017 and has been used to monitor the progress of the medium-term plan launched in 2017 to set priorities of the initiatives and determine the direction of measure development.

On the other hand, in LIME2, I felt it was an issue that the environmental impact of "water resource consumption" could not be achieved and that the evaluation was limited to within Japan as the business was expanding globally. In particular, in our business field, we can make a great contribution through our products in terms of water, such as the provision of water treatment plant equipment, including infrastructure materials. Therefore, by using LIME3 to evaluate the value and risk of “water” according to situation and area of each country including “overseas”, we considered if the evaluation results could be used as a tool or an indicator to find a direction of the new medium-term plan from 2020 or if the results could be used for product promotion.

2.2 Intended applications

We want to apply the survey results towards the next two major applications.

- Identifying the merits of use for each product

In this study, the main focus was on understanding the environmental impact of business development in each country and finding out the direction of measure development in each area.

- Evaluate potential for use as a tool to measure the progress and effects of ESG management within

the Sekisui Chemical Group.

(We also clarified the differences in the evaluation results from the previously used LIME2, and

proceeded with the study including consideration that the differences from the conventional disclosure information should be shown to stakeholders.)

3. Scope of the study

3.1 Study subjects and specifications

1kg plastic molded product as the intermediate material manufactured by Sekisui Chemical.

3.2 Functions and functional units

Supplying 1kg of plastic molded product

3.3 System boundaries

From resource mining to the production of 1 kg of plastic molded products (Cradle to Gate), and the disposal and recycling stages. (Fig. 3.3-1) To expand the range of possibilities for using LIME3, we examined several scenarios, such as the country of procurement and the location of manufacturing factories, that allow companies to formulate strategies. Specifically, regarding the process from raw material procurement to the manufacture of molded plastic products, we evaluated scenarios in the United States, Japan, the Netherlands, China, Thailand, Mexico, Nigeria, UAE, and Australia. For disposal and recycling, scenarios were evaluated in the United States, Japan and China.

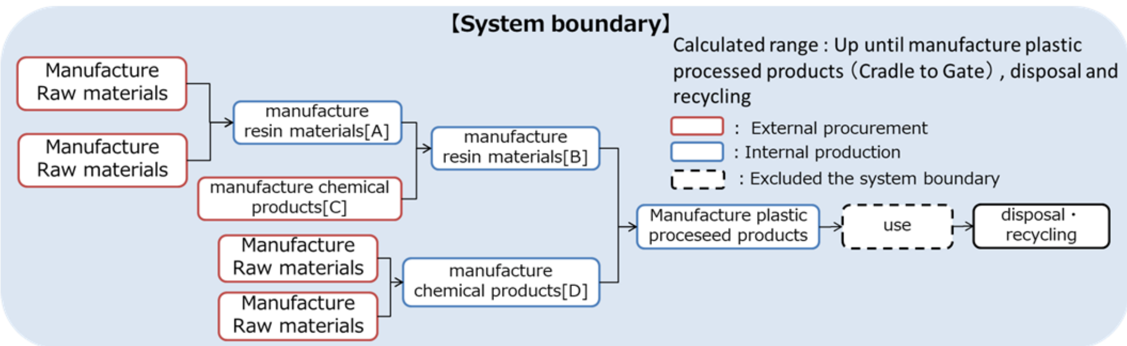


Fig. 3.3-1 System boundary image

3.4 Special notes (excluded processes, matters, etc.)

Since the use stage involves use as an intermediate material, it is difficult to grasp the actual situation of both use in a user company and use as a final product. As such, this was excluded from the study. Furthermore, raw material production and assembly and the construction, maintenance, and disposal of factories and machines related to fuel production, as well as tools and parts required for maintenance are not included in the assessment. Other important points in the supply chain were assessed using a simplified process flow.

4. Inventory analysis

4.1 Foreground data

Collection parameters for foreground data are as shown in 4.1-1.

Table 4.1-1 Foreground data collection parameters

Temporal effective range	FY2015
Geographical effective range	Japan. However, in order to consider the business development scenarios in each country being evaluated, the analysis was performed assuming that input and output for respective processes in those counties were the same as those for corresponding processes in Japan.
Technical effective range	Data on the production of plastic molded products is based on in-house operating results
Other data collection parameters	Input flow Main raw materials Main energy (power, fossil fuel, steam) Water (tap water, industrial water, groundwater) Output flow Product production volume Waste product (landfill, incinerator, renewable resources) Wastewater (rivers, sewer systems, etc.) No data gathered for land use or forest resources (Impact estimated to be minor)

The following three scenarios were assessed as disposal and recycling scenarios (Table 4.1-2).

Table 4.1-2 Scenarios for disposal and recycling

Scenario	Conditions
Landfill scenario	After dismantling, crushing and sorting, evaluate as 100% landfill.
Thermal recycling scenario	After dismantling, crushing and sorting, the cement industry recovers heat after incineration, which contributes to reducing fossil resource consumption.

Material recycling scenario	Considering that material (cascade) recycling is 100%, the environmental impact after dismantling, crushing, and sorting is not calculated (cut-off). The effect of replacing virgin material with recycled materials has not been calculated.

4.2 Background data

IDEAv2.2[i] was used as a background database. Note that IDEAv2.2 is based on Japanese production technology, so when interpreting the results, it was noted that the environmental impact was underestimated in overseas evaluations, especially in the assessment of developing nations. As for power data, Japanese system power data was used since we are assuming the use of Japanese production processes. By doing so, we thought it possible to eliminate the country-specific impact of background data and clarify the differences in results based on country-specific LIME3 coefficients.[i]

For the basic flow, the result of integrating LIME2 was calculated using MiLCA v2[ii], and the top 20 items with the highest contribution and the basic flow related to water resource consumption were adopted. The ratio of the total value of the top 20 items to the total integration result of LIME2 was 99.7%, which was considered to be a reasonable range for the purpose of this study.

4.3 Items in the inventory analysis and the results

A list of analyzed items and results in inventory analysis is shown in Table 4.3-1.

Table 4.3-1 LCI analysis results of plastic molded products

Resources/ Emissions	Collection/ discharge destination	Category	Basic flow name	Unit	Production	Crushing	Heat recovery	Landfill
Resource	Land	Non-renewable energy	Generic coal, 25.7MJ/kg	kg	3.59E-01	7.08E-03	-1.28E+00	0
Resource	Land	Non-renewable energy	Crude oil, 44.7MJ/kg	kg	2.11E+00	5.53E-03	-3.42E-02	0
Resource	Hydrosphere	Renewable materials	Groundwater, consumption	m^3	2.01E-03	1.44E-06	-1.40E-07	0
Resource	Hydrosphere	Renewable materials	Groundwater, transpiration, consumption	m^3	4.80E-06	2.67E-07	-2.08E-13	0
Resource	Land	Non-renewable energy	Natural gas, 54.6MJ/kg	kg	1.89E+00	9.04E-03	-1.50E-03	0
Resource	Hydrosphere	Renewable materials	Surface water consumption	m^3	3.64E-02	1.47E-05	-3.60E-05	0
Resource	Hydrosphere	Renewable materials	Surface water, transpiration, consumption	m^3	8.63E-05	4.78E-06	-3.75E-12	0
Emission	Air	Unidentified	CH_4 (fossil resource derivative)	kg	9.67E-03	2.75E-05	-1.19E-03	0
Emissions	Air	Unidentified	CO2 (fossil resource derivative)	kg	9.14E+00	5.70E-02	-6.30E-01	0
Emissions	Air	Unidentified	HCFC-22	kg	4.39E-04	8.59E-09	-2.11E-11	0
Emissions	Air	Unidentified	N_2O	kg	4.37E-04	3.28E-07	-2.19E-05	0
Emissions	Air	Non-urban area or high effective chimney height	NOx, urban area (chimney height)	kg	7.32E-03	2.04E-05	-2.47E-03	0
Emissions	Air	Non-urban area or high effective chimney height	PM2.5, urban area (chimney height)	kg	4.50E-04	6.16E-07	-2.13E-04	0
Emissions	Air	Non-urban area or high effective chimney height	PM2.5, non-urban area	kg	4.51E-03	3.45E-07	-3.61E-05	0
Emissions	Air	Non-urban area or high effective chimney height	SO2, urban area (chimney height)	kg	2.63E-04	2.47E-06	-2.30E-03	0

Emissions	Land	Within managed category	Industrial waste (landfill)	kg	1.93E-03		-8.63E-11	1.00E+00
Emissions	Air	Unidentified	Hydrocarbon	kg	1.10E-04	5.08E-07	-4.96E-06	0
Emissions	Air	Non-urban area or high effective chimney height	Sulfur oxide (SOx), urban area (chimney)	kg	4.70E-04	5.14E-06	-6.75E-06	0

5. Impact assessment

5.1 Assessment steps and impact categories

For the impact assessment, we used the Japanese version of the LIME2 and LIME3, Life-cycle Impact Assessment (LCIA) Method based on Endpoint modeling to evaluate integrated assessment. In addition, since multiple coefficient lists are presented in LIME3 and the user can select them according to the purpose, the options adopted this time are shown in Table 5.1-1. However, for crude oil and natural gas, the global average was applied. There are two reasons for this. The first was the determination that "the selection of oil and natural gas procurement countries cannot be assigned as corporate strategy." the second was that the problem of crude oil and natural gas resource depletion should be viewed as a global issue regardless of regionality.

Table 5.1-1 LIME3 options adopted

	Options adopted
DF or IF1 or IF2	IF2 (economic valuation) only
Resource consumption	Consuming country base. The crude oil and natural gas integration coefficient is the world average (however, Japan's integration coefficient is used when comparing LIME2 and LIME3)
User cost discount rate	3% (7% for sensitivity analysis)
Weighting coefficient	G20 (population-weighted)

5.2 Impact assessment results

5.2.1 LIME2 vs LIME3 integration result comparison

Figure 5.2-1 shows a comparison of the integration results of LIME2 and LIME3 when the factory location is Japan. As mentioned above, the results of the examination at LIME2 have been audited by the auditing organization as an integrated index since 2017, and then calculated and disclosed as a company. In this case, the sum of the integration results of LIME2 and LIME3 was almost the same. However, looking at the breakdown, there was a large difference in the aspects that had an impact. Since the integration results of LIME2 and LIME3 are calculated based on different unit, the rate conversions are: LIME2 weighting result: 100 yen = LIME3 weighting result: $1 US.

For example, looking at the results by impact category, the impact on urban air pollution is only a fraction. This is mainly due to the lower LIME3 integration coefficient of SOx. For the integration coefficient of air pollution, a separate evaluation model is used for LIME2 and LIME3. However, LIME3 uses a model that can more appropriately evaluate the effects of the widespread diffusion of PM2.5. This is because the impact of urban air pollutants emitted in Japan is relatively becoming decreasing. On the other hand, fossil resource depletion has almost doubled. The main factor is that the LIME3 integration coefficient for crude oil and natural gas is larger than that of LIME2. Regarding the integration coefficient of crude oil and natural gas, the survey time was different for LIME2 development and LIME3 development, and this is because LIME3 reflected the latest user costs. The impact of water resource consumption, which is a new evaluation item from LIME3, became apparent, although at a small ratio of several percent.

Furthermore, looking at the results by protection area, the contribution of social assets and biodiversity increased and the contribution of human health decreased in LIME3. The contribution of primary production was almost zero. The presumed reasons are that only social assets are subject to LIME3 (experimental) as a result of waste treatment, and land use and forest resource data were not included in this data.

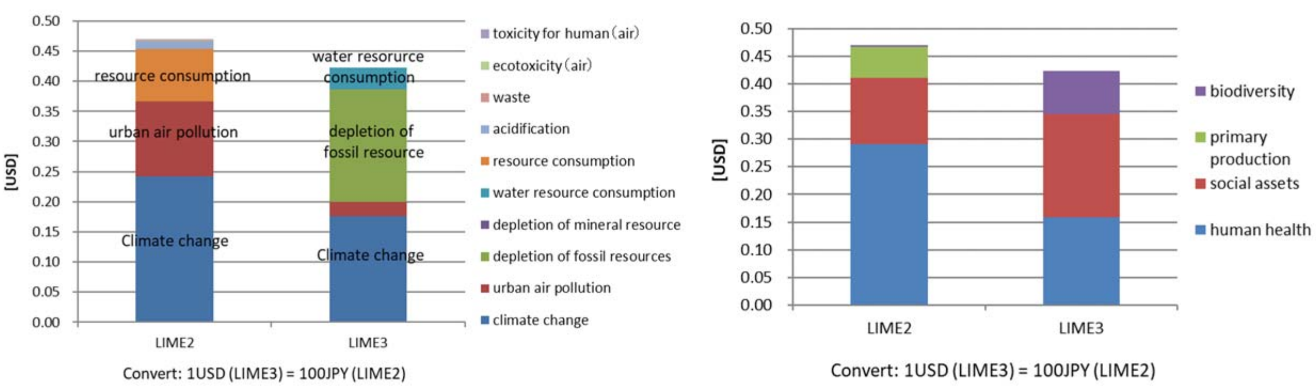


Figure 5.2-1 LIME2 vs LIME3 weighting result comparison

By impact category (left), by protection area (right)

5.2.2. Evaluation results according to business development (production activities) in each country

As described in section 2.2, in this study, we evaluated the merits of utilizing each product. In particular, our main focus was on understanding the environmental impact of business development in each country and finding out the direction of measure development in each area. As such, 5.2-2 shows a comparison of LIME3 integration results by country of factory location.

By impact category, we acknowledged that the contribution of fossil resource depletion is dominant and of high importance. We also recognized that global issues include fossil resource depletion and climate change, and local issues include urban air pollution in East and Southeast Asia and water resource consumption in Japan and Europe.

It can be interpreted that the major impact of urban air pollution in East and Southeast Asia is due to the relatively high population density and the proximity of contaminated areas to people. It can also be interpreted that the impact of water resource consumption in Japan is relatively large because the result is based on the model assuming that food production efficiency per water consumption in Japan is high, and if food production declines due to water shortage, damage including malnutrition will be induced in economically more vulnerable countries through food trade. .

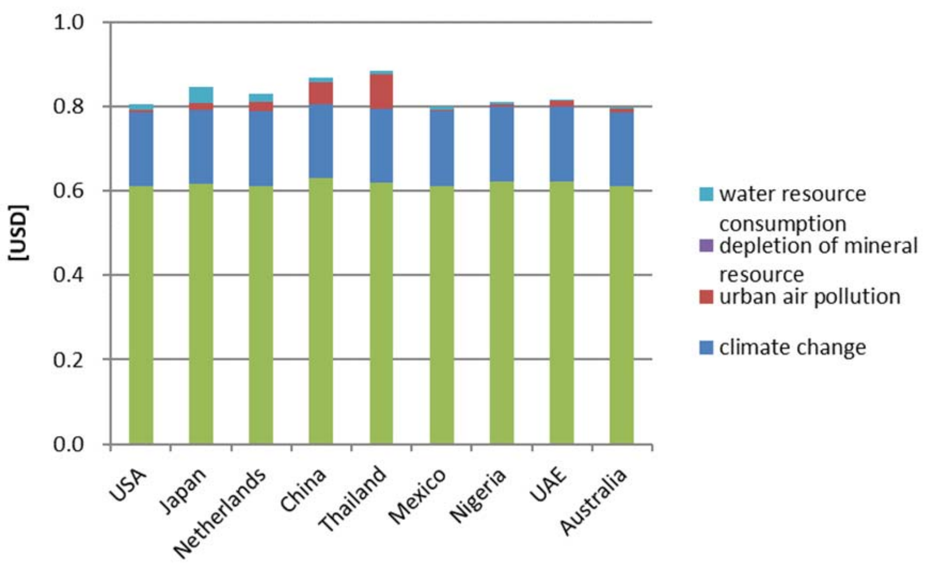
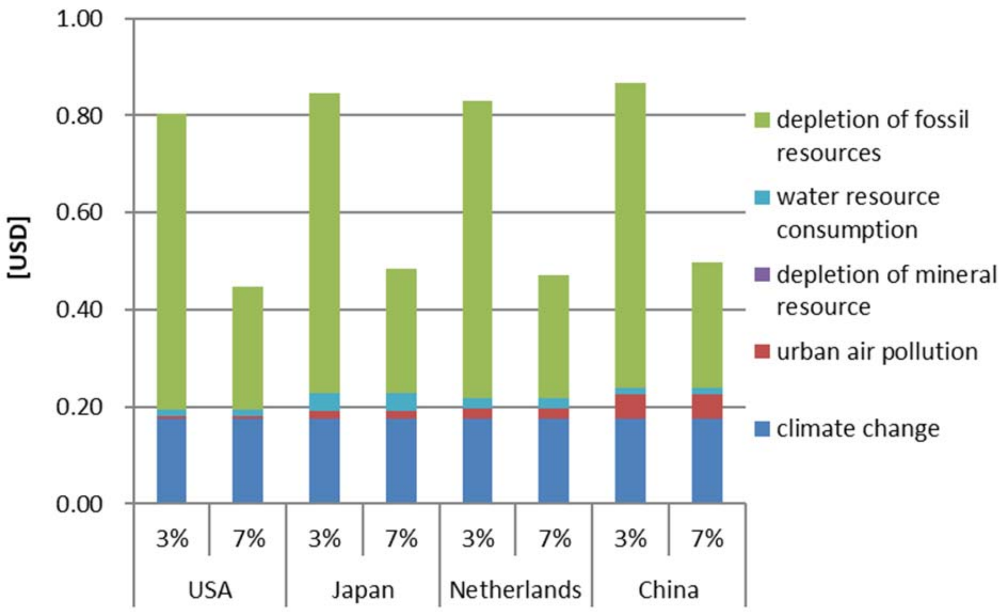


Figure 5.2-2 Results of LIME3 integration by country of plant location

Figure 5.2-2 shows that the contribution of fossil resource depletion is dominant. As described above, for items having a large difference from LIME2, the coefficient updated and set taking into account uncertainty has a large effect. Therefore, sensitivity analysis was performed to confirm the range of uncertainty. With LIME3, 3%, 5%, and 7% can be selected for the resource discount rate (how much the future value is discounted from the present value in consideration of future uncertainty). In this case, we conducted a sensitivity analysis to compare the results with an integration coefficient with a discount rate of 7% to confirm the impact of future forecasts on the contribution of fossil resources (Figure 5.2-3). Taking into account future uncertainties, the importance of the contribution of fossil resource depletion and the importance of climate change did not change. From this, it was reconfirmed that the most important issue in the products examined in this study was the depletion of fossil resources even if the situation changed.

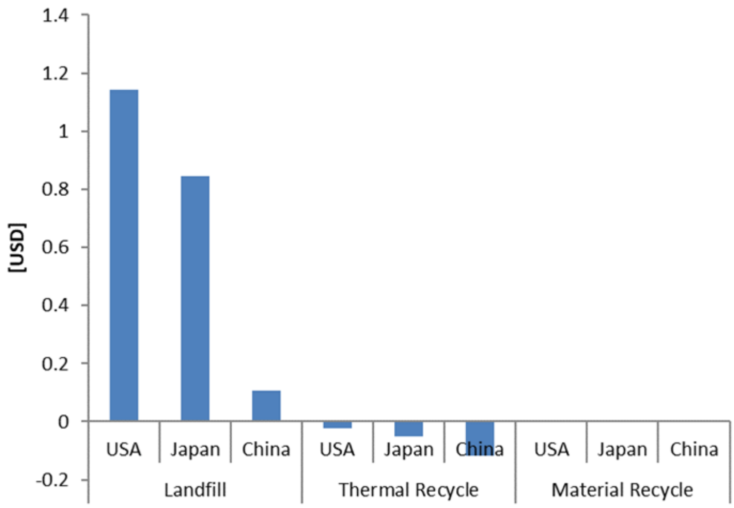


* Thailand, Mexico, Nigeria, UAE and Australia omitted due to space limitations

Figure 5.2-3 Sensitivity analysis of LIME3 integration results by country of factory location

5.2.3 Evaluation results of disposal and recycling

Figure 5.2-4 shows the evaluation results based on disposal / recycling scenarios of landfill, thermal recycling, and material recycling. Regarding landfill scenarios, the results of integration were small in China and large in Japan and the United States. In the landfill scenario, the cost of disposal and the number of remaining years affect user costs, which translates into a lower integration coefficient in China. Regarding the thermal recycling scenario, negative integration results were large in China and small in Japan and the United States. In other words, it shows that the effect of subtracting the environmental load by replacing the grid power with thermal recycling was significant in China. Regarding material recycling, the integration result was almost zero in all countries because, as described in Table II 4.1-2, material (cascade) recycling is considered to be 100%, and the environmental burden after disassembly, crushing, and sorting is not calculated (cut-off treatment).



* Evaluated only in the United States, Japan, and China due to space limitations.

Figure 5.2-4 Results of LIME3 integration at the disposal / recycling stage

6. Conclusion

6.1 Summary of the results

An integrated evaluation of plastic molded products from raw material procurement to production and disposal / recycling was conducted. The recommendations gained through those results are described below.

The important protection areas were social assets: consumption of fossil resources of crude oil and natural gas, and human health: climate change and air pollution and water resource consumption. From this, the magnitude of the issues was re-recognized by the global evaluation and new evaluation items.

Environmental measures considered to be important suggest that the procurement of raw materials (maximization of recycling, conversion to bio-based raw materials), promotion of energy saving and introduction of renewable energy, not limited to our own factories, have the potential to reduce environmental impact.

It was important to consider local issues depending on the location of the company's factories, especially air pollution issues in Southeast Asia and water issues in Japan and Europe. When manufacturing in East Asia, Southeast Asia, etc., it is necessary to pay more attention to air pollution than in Japan. Water is indispensable in the reaction process for resin production, and water is required for cooling during molding. At this stage, it is important to consider water consumption with an emphasis on direct risks, such as the potential of water sources in the area and the load on discharge destinations.

Regarding the disposal and recycling of used products, it is important to note that the waste coefficient (social assets) in LIME3 at this stage is a preliminary calculation, but as long as the current status of the disposal system in each country continues, we would like to try not to landfill in Japan and the United States.

From the above, it was concluded that it is necessary to consider further measures to reduce the environmental burden of each country in each process, taking into account the economic situation according to each environmental aspect and impact category.

At present, with regard to local water issues in Japan, measures to improve both quantity and quality will be implemented from FY2018, and the results of this study will support the promotion of these measures.

It was also recognized that the difference between the integration results of LIME2 and LIME3 was largely due to differences in the way of thinking about the integration coefficient and how to handle them. The study also recognized that there is uncertainty in the weighting coefficients, and that the use of the weighting results should be implemented with consideration to the impact of the uncertainties of the coefficients and recognizing that scope. This is one of the things we considered during this evaluation.

6.2 Limits and future issues

In this evaluation, the comprehensiveness of the targeted processes (resin material production, resin production, disposal / recycling) covered important processes, and the validity of the results is considered to be secured. On the other hand, IDEAv2 used as a background database has limitations due to the modeling of Japanese production processes. In other words, in the production process in Japan, environmental facilities for preventing air and water pollution are in place. If applied overseas (particularly in developing countries), there is a possibility that the environmental impact will be underestimated. Summarizing this issue, note that environmental impacts may be underestimated in overseas (particularly in developing countries).

In addition, although the subject of this study is one of our plastic molded products, it is presumed that similar trends can be obtained in products used for other purposes. However, since horizontal recycling is not evaluated, this is excluded. In the future, we will consider the use of LIME3, taking into consideration the assumptions at the stage of use.

At this stage, it was found that the use of LIME3 could give more detailed suggestions because it could be considered by region to reduce the environmental impact of the product life cycle.

We judge that this shows that it can be effectively used in both the development of measure and the market.

On the other hand, these interpretations were obtained by confirming the coefficient characteristics of LIME3 with teachers of LIME3 method developers. It is difficult to infer these interpretations from the results of integration, and we believe that certain considerations are needed to explain the event to stakeholders. In other words, explaining the differences in the results of integration with the conventional method to stakeholders and explaining the differences in each country require some expertise and comprehension. We want to consider LIME3 utilization while considering whether it is easy to understand.

Reference literature
[i] LCI Database IDEA version 2.1, National Institute of Advanced Industrial Science and Technology, The Research Institute of Science for Safety and Sustainability, Society and LCA Research Group, Industrial Environmental Management Association
[ii] LCA system MiLCAver. 2, Japan Environmental Management Asociation for Industry