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Contents

Development of LCA Studies and Future Expectations

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LCA must become a "tool" instead of a "procedure" if it is to be used for general-purposes. To make LCA into a "tool," then it is necessary to develop an infrastructure that allows everyone to implement LCA. The core elements of the LCA infrastructure are (1) inventory databases and (2) impact assessment methods. Development of these depends on the research sector, and I believe the participation of researchers is meaningful. In this article, from the standpoint of a researcher, I would like to describe the future LCA study trends based on the current LCA study status.

The recent LCA study trends are as follows:

- Development of the concept and data of LCA into other tools or ideas
(LCC, LCM, industrial models, environmental efficiency, and so on)
- Integration of knowledge of other fields of study in order to improve the standard of LCA (procedures)
(incorporation of biology, toxicology, medical science, immunology, sociology and economics)

While the former is an "outward" development based on LCA studies, the latter is an "inward" development in which other study fields are integrated into LCA studies. Although there is no doubt that LCA has an extremely important role to play in society, I realize that there will be difficult challenges and issues as follows during the course of promotion of the abovementioned "outward" and "inward" developments.

First, the former (LCA -> other evaluation assessment tools) is examined here. In the 1990's, LCI case example research was established as a study theme. However, the understanding that the LCA infrastructure is now fully developed has been spreading, and it is difficult to take initiative using only LCI. In fact, at the recent general meeting of the Society of Environmental Toxicology and Chemistry (SETAC), the number of presentations on LCC and LCM dramatically increased. Therefore, development of the LCI and LCIA methods is now starting to be categorized as “basic” LCA research.

It should be noted, however, that the "basic" LCA research must not be neglected because the attention of many LCA experts is now shifted to advanced studies. Since nature and technologies are always changing, overlooking obsolete data may cause extremely serious problems. While LCA continues to develop rapidly, without anyone noticing them, gaps have been emerging between what LCA implementers want from researchers and what researchers are interested in. Therefore, it is necessary to establish appropriate measures in order to provide LCA researchers with incentives for rediscovering the importance of basic LCA research.

Next, let us examine the latter case (environmental science in various fields -> LCA studies). For the past few years, LCIA has made rapid progress and this progress is mainly attributed to the development of new aspects of the LCIA method by integrating useful knowledge in other environmental science fields. As a result, research on LCIA method development is becoming more and more like multidisciplinary research. When this occurs, support for "basic studies" such as immunology or air quality research becomes necessary in LCIA studies. However, the importance of "new social needs" in terms of LCIA studies has not been recognized in the area of basic studies mentioned here. This is the gap among researchers from various academic fields regarding social needs. Unless this gap is eliminated, multidisciplinary research cannot be meaningful.

In Europe, research on risk assessment mainly for chemical substances and research for establishing an LCIA interface have already established their positions. Academic conferences such as the SETAC greatly contribute to continuous development of LCA studies.

LCA researchers are responsible for continuing examination of "basic LCA research," and in order to realize sustainable improvement of the basic LCA research standard, it is essential to establish a system which allows the "basic study fields" such as biology to contribute to LCA. Also, in order to improve the quality of "advanced LCA research" such as environmental efficiency or eco-labels, those who are involved in the advanced research must inform the basic-study side of social needs. Through this process, the importance of basic studies can be rediscovered, and well-balanced research and development can be realized.

Such interdisciplinary systemization can be effectively realized if some academic society takes the initiative. It is desirable that an organization or academic society leading LCA studies actively contribute to the promotion of interdisciplinary communication such as basic studies (LCA) <- -> advanced LCA research, and basic studies to be used in LCIA <- -> research on LCIA method development. I expect that such activities will be proactively carried out at the LCA Society of Japan or the Institute of Life Cycle Assessment, Japan.

Case Study

Utilization of Environment Labels

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1. Introduction

We are making efforts aimed at making a sound material-cycle society that uses the limited natural resources efficiently while reducing environmental burdens and ill effects on the global environment.
Our company has developed, as metal containers that give due consideration to the environment, two-piece cans called “TULC” and “aTULC” that are formed using polyester laminated metal plate by “dry forming” without using water.
Toyo Seikan has been pursuing the activity of attaching environment labels for the purpose of promoting to the manufacturers who fill their products into the containers, in addition to appealing directly to the consumers the environmental superiority of metal containers using laminated materials such as TULC.
In the following, we describe some examples of utilizing environment labels of the environment friendly type metal cans of the “TULC” series.

2. Environment Friendly Type Metal Cans “TULC”

Conventional DI cans (Drawn & Ironing cans) are formed by using large amount of lubricant/coolant, then solvent and carbon dioxide are emitted from the lacquer coating and baking process. It was found that decreasing these environmental burdens was the main issue.
Toyo Seikan developed new can manufacturing system called TULC by utilizing polyester laminated metal plate and dry forming process, to solve the problem. This process doesn’t need conventional lubricant/coolant and eliminates lacquer coating. So the environmental burdens generated from the can manufacturing processes were reduced remarkably.

Figure 1 shows a comparison of the main environmental burdens during the manufacture of TULC and aluminum DI (ADI) cans.
Since TULC cans are formed using a polyester laminated material, the lacquer coating and baking on the inside of the can after its forming is not necessary, and as a result, the amount of carbon dioxide emission could be suppressed to less than 1/3 of conventional DI can manufacturing. This is because the energy consumption decreased with the elimination of baking process, and no discharge of carbon dioxide due to the burning of solvents during the discharge gas treatment.

Further, since large amount of lubricants and coolants are not used in this can manufacturing system, there is no need for the washing process after forming and the cleaning water discharging processes, and hence the amount of water used effectively became zero. In addition, since there is no generation of sludge associated with the waste water treatment process, the solid waste material generated in the can manufacturing processes became extremely small.

3. Utilization of Environment Labels

We not only strongly introduced the environmental superiority of TULC to the customers right from the time it was put on the market, but also made presentations in academic conferences, lecture meets, and exhibitions, and carried out promotion activities by distributing pamphlets, etc. These activities were mainly those aimed at our customers who fill their products in the cans, and were not directed at the general consumers. Further, since our company is a manufacturer of containers, and since the end product is sold as a brand of the contents in the containers, we almost did not do any advertising promotion towards the general consumers.

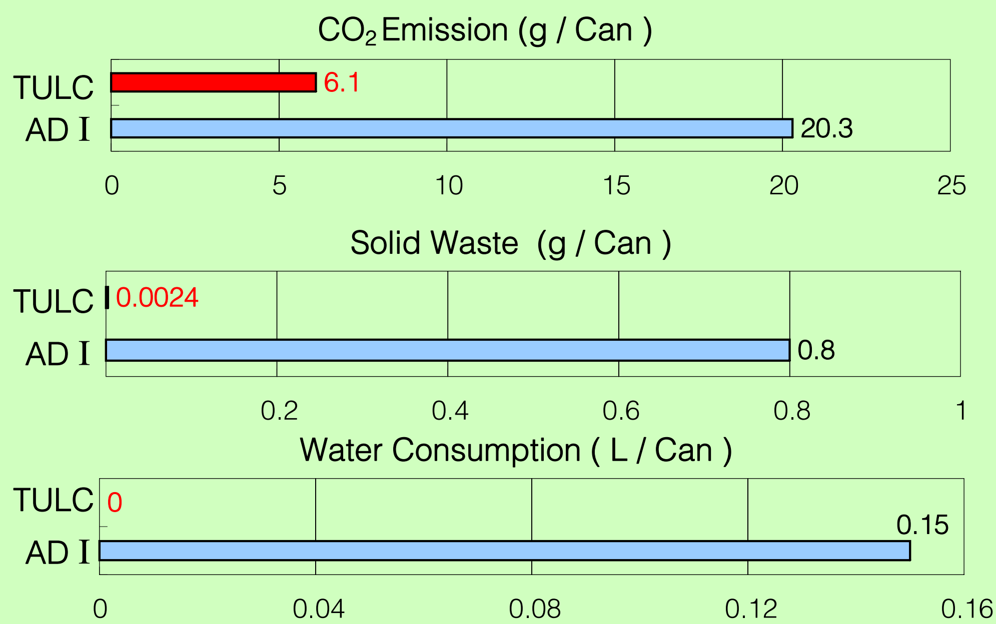

Fig. 1 Comparison of environmental burdens during can manufacturing (per 350ml can)

In view of this, as a means of selection for the general consumer at the time of purchase, we considered that it is necessary that they understand that it is an environment friendly product, and clearly indicated environment labels on the products and carried out expanded sales while appealing along with the brand owner.

Although initially we investigated acquiring the certification of type I environment label (Eco mark), but since it was difficult at that time to get the Eco mark approved for metal cans because of the approval standards (product category and criteria of metal cans), we affixed the type II environment labels which are of the self declared type.

3.1 Type II Environment Labels

Type II environment labels are labels affixed by the manufacturer to claim the environmental superiority of the products at the responsibility of the manufacturer. Toyo Seikan adopted an environmental label in cooperation with Q.P. Corp. from 2003 onwards and put these labels on cans of meat sauce and sauces for cooking. In these labels, explanatory text about the environmental superiority of TULC cans used as the containers is printed along with the logo mark on the outside of the cans. These logo marks can be put on all TULC products adopted by all customers.
Here, it was clearly stated that "CO_2 emission during can manufacture is made smaller compared to conventional cans, and the cans are formed without using water."
However, since the type II environment labels are merely self-declaration type labels, it was considered necessary to provide environmental information that can be trusted more, and we started activities to acquire the qualification of the type III environment labels.

Fig. 2 Type II environment label of TULC and examples of products using them

3.2 Type III Environment Labels

The type III environment labels are affixed along with disclosure of environmental information according to some fixed standards stipulated by a third party organization. The "EcoLeaf" mark approved by the Japan Environmental Management Association for Industry (JEMAI) is the most famous Type III label in Japan. The consumers can get the environment information of that product by searching the registration number on the website of JEMAI.

Although this label is not one that judges the superiority or inferiority of the product, disclosure of environmental information is an essential social responsibility of a company, and obtaining type III environment labels is spreading in the world.

We considered that it is important to disclose the environmental information about containers, proposed establishing the Product Specification Criteria (PSC) in the field of "Metal cans for beverages and foods", and carried out activities towards their establishment.
About ten companies participated in the Working Group during the preparation of PSC draft, and discussions were repeated regarding the detailed standards for LCA evaluation for EcoLeaf. (February 2004 to May 2005)
Here, the a similar method to the "Investigation Report on Life Cycle Assessment of Container and Packaging" that was implemented by the Ministry of Environment of Japan from fiscal 2002 to fiscal 2004, particularly, the treatment of recycled materials was defined clearly, and considerations were given so that there is no inequality depending on the type of container.

Conventionally, although a method had been proposed that evaluated only closed loop recycling in which recycling was done from cans to cans, we considered that this would attend to only a part of the problem and worked towards evaluating properly even the so-called open loop recycling in which recycling is done for purposes other than cans.

In addition, although so far it is common not to include the burdens during the process of filling the containers since the contents filled are varied, it has this time been decided to include the environment load of filling in two types of scenarios (carbonated drinks and retort drinks) so that in the future the filling manufacturers can study EcoLeaf including the environmental burdens of manufacturing and filling the contents.

No. BC-05-001

Fig. 3 EcoLeaf environmental label

Immediately after the PSC of metal cans was established, Toyo Seikan's TULC series products were acquired the qualification of EcoLeaf Labels. Toyo Seikan has already acquired the qualification of EcoLeaf Labels in 17 metal can types. And their environmental information are disclosed on JEMAI's website (Fig. 4).

Further, products with the EcoLeaf mark printed on them are introduced in the market from March 2006.
Website of Japan Environmental Management Association for Industry (JEMAI):
http://www.jemai.or.jp/english/ecoleaf/

4. Conclusions

We consider that making public the information of containers having superior environmental performance is equal to “responding to the trust of customers”, and will continue our efforts to promote our customers (the filling manufacturers) who have adopted out TULC series products to put the “EcoLeaf mark” in their products.

	Resistration No.	Probuct Name	Can Code
1	BC-05-001	TULC 200ml Low Vacuum	J200TF2-S
2	BC-05-002	TEC200	J200TF2R38
3	BC-05-003	aTULC 350ml 204End	B350TL14
4	BC-05-004	aTULC 500ml 204End	B500TL14
5	BC-05-008	TULC 160ml Low Vacuum	J160TF2-S
6	BC-05-009	TULC 175ml Low Vacuum	J175TF2-S
7	BC-05-010	TULC 250ml Low Vacuum	J250TF2-S
8	BC-05-011	TULC 280ml Low Vacuum	J280TF16-S
9	BC-05-012	TULC 280ml Normal Vacuum	J280TF16
10	BC-05-013	TULC 280ml For Food	J280TF18
11	BC-05-014	TULC 350ml Low Vacuum	J350TF16-S
12	BC-05-015	TULC 350ml Normal Vacuum	J350TF16
13	BC-05-016	TULC 200ml Pressurized	C200TF2HF
14	BC-05-017	TULC 280ml Pressurized	C280TF16
15	BC-05-018	TULC 350ml Pressurized	C350TF16
16	BC-05-019	aTULC 350ml 206End	B350TL16
17	BC-05-020	aTULC 500ml 206End	B500TL16

TULC (Steel can)

aTULC (Aluminum can)

TEC (Steel can)

Fig.4 Qualification of EcoLeaf Labels (as of Feb. 2006)

Case Study

LCA Information Disclosure Using Eco-Leaf Environment Labels

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1. Introduction

LCA is used as a method of evaluation when a company is reducing the environmental load over the life cycle of a product or service through environmentally conscious design. At the same time, a large number of companies also have the intention of disclosing the result of LCA as environmental information. There are various purposes for such disclosure by companies such as publicizing the corporate philosophy, distinguishing from competing companies, etc., but one of the fundamental purposes is to present the users with LCA information as the product environmental information, and to make the customers buy products that are environment friendly. Even if a product is designed friendly to the environment over its entire life cycle, those environmental considerations will not be realized if that product is not sold. At this time, communication using product environmental information is necessary between the company and the purchasers. As a tool of disclosing such LCA information, the type III environmental label in Japan, the Eco-Leaf, has entered its fifth year since its inception in 2002. The number of label registrations and disclosures is increasing firmly and has reached 429 cases (cumulative total of 554 cases) as of the end of February 2007, with 47 companies disclosing the labels. Even the product classes have increased in number and reached 53 product classes, and even materials and intermediate products are increasing (Fig. 1 and Table 1). In this paper, we discuss the outlines of what factors have to be considered when a company is implementing LCA for the first time and is disclosing its information. Further, we also discuss how the Eco-Leaf helps in this context.

2. Factors to be Considered at the Time of LCA Information Disclosure

Use of LCA can be considered in various phases of environmental conscious design by a company such as determining the major environmental aspects at the initial stages of development, or

Fig 1 Registered Eco-Leaf by Product Categoly (As of Feb,2007)

Current ratio by product category

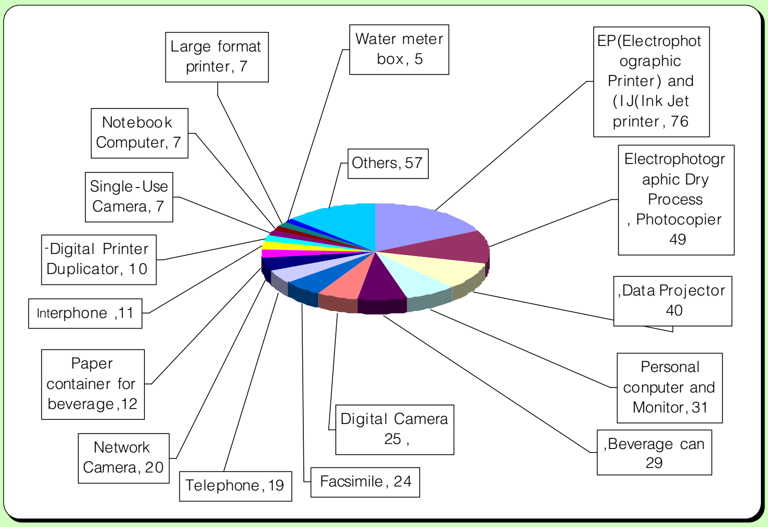

Table 1 Registered Eco-Leaf by Product Categoly Others (As of Feb,2007)

Product Category	No of	Product Category	No of
Flatbed/Sheet-fed scanner	5	High voltage board switch gear	2
Instant Photo Printer	4	Analog Camera	1
PBX system	4	Bidet Toilet Seat	1
Foamed polystyrene sheet	4	Structural Aggregate	1
Small format photo printer	4	Grid Electricity	1
Electronic board	3	Drain Ditch Cover	1
Free access raised floor	3	Photo Print Scanner	1
Low-voltage motor control center	3	Save Electricity Equipment for Fax	1
Tile carpet	3	Wholesale electricity	1
PS foam insulation material	2	Electronic voting system	1
Thermal transfer card printer	2	Internet data server system	1
Optical Disc Drive	2	POS terminal	1
Touch and close fastener	2	Industrial chain	1
Water meter unit	2		

verification of the effect of environment conscious design, etc. The outlines of the items to be considered at the time of actively disclosing the results of these LCA to the purchasers are discussed below.

LCA implementation standard for information disclosure

For the purchasers to select and buy environment friendly products, instead of information such as image advertisements, it is necessary to provide LCA information of the product such as how much environmental load is generated concretely for each unit of the individual product or service, how much the environmental performance has improved of the product that has appeared in the market, etc. When such quantitative information is disclosed to the purchasers, it is important that such information is based on LCA implementation standards with a certain level of concreteness.

Implementation of LCA

For a company, it is efficient to form beforehand a system inside and outside the company having several functions of data gathering, data processing, data verification, and also LCA information disclosure, etc. While it is relatively easily possible to collect data directly of the assembly processes within the company, very often it is difficult to gather directly the upstream data in the supply chain.

Objectivity of information

The receiver of LCA information can accept the information with reassurance if it has been verified by a third party. Even if a company is trustworthy for a consumer, verification by a third party further enhances the reliability of the information. In addition, a company can extract from the LCA information the points that can be presented as effect of environment conscious design and disclose it as an environmental report, etc. At this time, if it can be indicated that the information has been verified by a third party, then the power to convince the consumers gets enhanced.

Format of LCA Information Disclosure

When large purchasers such as government bodies and purchasing departments of companies read the LCA information for purchasing, it is convenient if that information is formatted in an organized manner and if it is possible to read the information for various types of products in a single web site. The products are not only end products. There are increasing numbers of cases of manufacturers of materials and intermediate products transmitting LCA information to end-product manufacturers. Even in such cases formatting is important. In addition, when common consumers read the LCA information, since they are not used to the concept of LCA and since the volume of information is large, it is important to format the LCA information so that the most important result in the LCA information is communicated first and then the intricate details are given to the reader as necessary.

Spreading of LCA

In order to constitute a sound material-cycle society, it is necessary to nurture the product market based on the communication of LCA environmental information and to make to take root firmly in the society. It is difficult to get the ordinary consumers to accept results of LCA as concrete information rather than just giving a fuzzy image of being "kind to the environment". Advanced companies and purchasers have started environmental communication using LCA information, and it is necessary to promote its widespread use further.

3. Features of Eco-Leaf

As can be seen from the above overview, while it is necessary to consider various aspects when a company implements LCA, we study in the following how Eco-Leaf is being useful in these aspects.

(1) Product Category-wise Standards for LCA Information Disclosure

One of the important schemes of Eco-Leaf for enhancing the reliability of LCA information disclosure is the product category rule. In the international standard ISO 14025 (issued in 2006), in the type III environmental declaration program including the Eco-Leaf, product category rules (PCR) were prepared after discussions among the parties having interests and disclosure of environmental declarations are to be carried out based on these. The Eco-Leaf is different from independent LCA of companies themselves in that it uses rules that are prepared based on consensus among companies. The rule proposals are prepared upon discussion among interested parties such as industry organizations, companies, etc., and the product category rules of Eco-Leaf are discussed and approved by a committee consisting of knowledgeable persons such as persons with academic experience, representatives of consumer organizations, LCA experts, etc.

There are two main purposes of product category rules. One purpose is to disclose to the readers various preconditions and assumed conditions associated with the LCA information along with the LCA information. The Eco-Leaf information is a pair with the product category rules, and the readers can refer to the product category rules corresponding to each label whenever necessary in the homepage.

Another purpose is to make the LCA methods, etc. standardized. When we take the point of view of increasing the ability of the LCA information to be shared, or of preventing confusion of the reader when seeing the Eco-Leaf labels of several products, in general, it is can be considered desirable to make the LCA methods or the background data, etc., common for each product category. For example, if strong commonness is carried out such as fixing the region of directly gathered data, limiting the background data only to specific common base units, limiting the logistics or disposal recycling scenario to one, etc., it becomes clear that the differences in the data between different product labels has its origins in the directly gathered data. However, such strong commonness measures are not necessarily suitable for product environmental information. This is because, as the commonness becomes stronger, the extent of the gap between the reality of product life cycle and the common rules becomes widely different for each product, and the considerations of the company towards the environment may not be expressed due to being tied by the common rules. On the other hand, if these common rules are removed and it is made possible to prepare the rules under free standards, it may be possible to express detailed numerical values according to the environmental considerations for each product. However, in this case, since there are more causes for differences in the data of the product labels, it becomes difficult to interpret them. In other words, in one aspect, there is a tradeoff relationship between increasing the commonness in the LCA method and the background data and the ability of LCA to express in detail; therefore it is necessary to adjust where to achieve a balance between them. This adjustment is being done in the case of the Eco-Leaf through the process of adopting the product category rules. Regarding generic data, in Eco-Leaf, although at present about 148 types of generic data have been prepared for the entire program, apart from these, it is also possible to use generic data that are common only within the product class and generic data special for each product. In addition, through revisions of the rules, it is possible to reflect as needed the trends of the product technology, trends in the LCA research, and the needs of the society.

(2) Support of LCA Implementation Through Eco-Leaf Base Units and Dedicated Software

As a rule, Eco-Leaf takes the entire life cycle as the target of evaluation. However, even if the directly gathered data of the upstream side cannot be obtained, if only the weight for each constituent element in the parts table is calculated, there is a simplified LCA scheme of assigning them respectively to the Eco-Leaf generic data. In addition, the Eco-Leaf data is divided into disclosed part and non-disclosed part, and when a company prepares the label, it first enters the information of the parts list or the directly gathered data obtained within the company in the non-disclosed part. Once the non-disclosed data is input, most of the parts of the disclosed label are generated automatically by the label preparation supporting system (dedicated software). Compared to the type III environmental label programs of other countries, the format and the entered items of the Eco-Leaf are relatively unified. This not only is easy to read for the readers, but also leads to simplification of the work of preparing the labels, and to making the work of verification efficient. In addition, from the point of view of ease of reading, at the stage of verification and judgment, verification is also made as to whether or not the expression in the label is easy for the reader to understand, and improvements are made as and when necessary.

(3) Achieving both third party verification and speed-cost of label acquisition

A certain time and cost are needed for data verification in order to assure objectivity of the information in a type III environmental label. In the Eco-Leaf, each Eco-Leaf label prepared by a company is subjected to third party verification by an external inspector, and the result of that verification is judged by a reviewing panel after which the label is registered and laid open to the public. This mechanism is being called external verification. However, it goes without saying that the time and cost involved in issuing a product label is very important for a company, and there will be problems particularly when there are a large number of products that a company desires to be disclosed. In view of this, in Eco-Leaf, as another verification route other than external verification, another system is prepared of internal verification based on system certification. System certification consists of verifying whether or not the business has maintained a system of collecting quantitative environmental information data, and examining and certifying whether that system has appropriate, valid, and continuing functions. If system certification is obtained, external verification for obtaining each label thereafter becomes unnecessary. In this case, the company does not have to consider the timing of the panel examination necessary for third party verification, and has the advantage of being economically beneficial when issuing a large number of labels. In the case of internal verification based on system certification, the third party nature of the individual label verifications are assured by the system examination carried out every three years.

(4) Contributions in Spreading LCA among Purchasers

As was explained in the beginning, while on the one hand LCA is used as an evaluation tool for gradually reducing the environmental load during development, on the other hand the purpose of transmitting environmental information at the time of purchasing is growing in importance. This is because, in order to realize the reduction of the environmental load over the entire life cycle, participation of the purchaser is also becoming important in addition to the participation of the companies themselves. Eco-Leaf is a tool for such environmental information transmission. The purchasers actively utilizing Eco-Leaf are not only the large scale procurers such as companies and governmental bodies but also the so-called green consumers who are the ordinary consumers having high environmental awareness, and this has become the motive force behind the dissemination of Eco-Leaf. On the other hand, for the majority of ordinary consumers, it is necessary to introduce afresh the concept itself of life cycle of products and services that are the basis of Eco-Leaf. Conversely, again, in order to propagate the concept of life cycle, the Eco-Leaf is a very good tool as it is concrete product information that is close to the consumers. The role of Eco-Leaf is very important as a basis for spreading the circle of people knowing the concept of life cycle from advanced purchasers to ordinary consumers, such as the Eco-Leaf activity of product information reports in the media or seminars of green procurement aimed at ordinary consumers.

4. Conclusion

In this paper, we have described the features of Eco-Leaf from the point of view of whether the Eco-Leaf environmental label is being of use when disclosing LCA information to the purchasers of products and services. In addition, it is recommended to refer to the homepage of JEMAI given below for details of the overall scheme of Eco-Leaf, the procedure of obtaining the label, etc.
http://www.jemai.or.jp/english/ecoleaf/index.cfm
Inquires can also be emailed to:ecoleaf@jemai.or.jp

Review

The Eco Mark Program and Product Life Cycle Assessment

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1. Introduction

Eco Mark is an "environmental label voluntarily attached to products upon approval of third parties" implemented by the Japan Environment Association since February, 1989. More specifically, Eco Mark is a part of the "type I environmental label program" standardized as ISO/14024. By attaching "Eco Mark" labels to products that are recognized as being environmentally friendly due to reduction of environmental burdens associated with daily life, the purpose of this program is to freely provide information on the environmental aspect of products and to encourage customers who wish to be environmentally friendly to choose the products with that label.

The following LCA (Life Cycle Assessment) procedures are used in the Eco Mark program:

(1) Examination of environmental burdens on the entire life cycle when establishing the product approval criteria ("life cycle consideration).

(2) Examination of preceding literature based on LCA data during a special review meeting to solve particular issues.

(3) Examination of creation of new product categories by the LCA task group.

(4) Estimation of reduction of environmental burdens in the domestic market attributed to certain Eco Mark products.

For these LCA procedures in the Eco Mark program, this report will provide a complete description of (1) and an overview of case examples of (2) to (4).

2. Product certification criteria statement in the Eco Mark program

2.1 Establishment of Eco Mark product certification criteria

Before certifying Eco Mark products, the certification criteria for the "applicable product category" for that product must exist.

In March, 1996, the Eco Mark certification criteria establishment method underwent major revision in response to the development of standardization of environment labels by the ISO and to the review meeting report by the environment agency[1)]. Currently, the certification criteria are established in the following manner. First, the "WG (working group)" for creating draft certification criteria is established. In accordance with the ISO's recommendation that a WG is "where interested parties have discussions," a WG has a well-balanced member composition of the suppler of the product undergoing scrutiny (first party), purchasers (second party), and neutral experts (third party), with approximately the same number of participants from each party. The Eco Mark Committee for Establishing Category and Criteria, which examines the draft criteria developed by the WG and establishes new criteria, has the same member composition to provide suppliers consisting of industry members and purchasers consisting of consumers and environmental NGOs with the opportunities to hold discussions during creation of the draft certification criteria.

When the product certification criteria were established, it was also established that the environmental effect of the entire product life cycle must be considered, as described in Section 2.3. Currently, the Eco Mark certification criteria have been established such that 5% to 30% (average of 20%) of the market-leading products having the same features can meet them.

2.2 Assessment of environmental effect of product life cycles

When the WG examine a product, the "product life stage-specific environmental effect item selection chart" shown as Table 1 is used to first identify environmental burden items for each product life stage, from manufacturing to disposal. This chart is created based on the abovementioned report[1)] and has almost the same structure as "an example of a product environmental criteria selection matrix" which is introduced as an example in JIS Q 14024 (ISO 14024).

Then, the WG carries out qualitative or quantitative examinations on the items that were identified as issues to be examined, and develops draft criteria as necessary. Table 1 and Attached Document 1 are cited from the certification criteria statement of product category No. 111 "Board Made of Wood or the Like Version 2.0." In this example, the WG discussed environmental burden items for the cells with the [O] or [@] symbol in the table during the course of establishment of the certification criteria, and for the cells with the [@] symbol, the environment-related certification criteria were established as a result of the discussion. The background of establishment of the certification criteria is provided as "explanation" in the certification criteria statement for each product category, and in that, as shown below, a summary of the discussion regarding individual [O] and [@] symbols (A-1, B-1, , and F-9) is provided.

A. Raw material collection phase

A-1 [Consumption of resources] The following points were reviewed under this term:

(1) The ratio of reused / unused timber as wooden parts shall be 100%.

(2)...

As for (1), from the viewpoint of preserving forests through effective use of non-used resources and re-use of timber, it is desirable that raw materials for the concerned product are 100% reused / unused timber.

Therefore, this was selected as the item for which the criteria should be established. As indicated in the terminology, the scope of reused / unused timber has been clarified. Considering the fact that forests that need to be protected have been degrading or they have been shrinking in size due to deforestation taking place faster than forest growth, use and processing of unused materials with innovative technologies are considered meaningful.

As for JIS A 5905 "Fiberboards" and JIS A 5908 "Particleboards," too,...

Table 1 Product life stage-specific environmental effect item selection chart

Environmental burden item	Product life stage					
	A. Raw material collection	B. Manufacturing	C. Distribution	D. Use/ Consumption	E. Disposal	F. Recycling
1 Consumption of resources	@		@		@	
2 Release of global warming substances	O	@	O			
3 Release of ozone depleting substances						
4 Impact on ecosystem						
5 Releas of air polluting substances		@	@	@	@	
6 Releas of water polluting substances		@				
7 Generation/Processing/ Disposal of waste					O	
8 Use/Release of hazardous substances	@	@	@	@	@	
9 Otherenviromental burdens	O	@		@		O

Although this discussion is not necessarily a quantitative LCA, it is still a procedure adopted in ISO/14024, and the purpose of the discussion is to make sure that major environmental burdens are not shifted to other life stages or other environmental burden items as they are (in other words, its purpose is to identify "trade-off" relationships). That is to say that it is necessary to realize reduction of environmental burdens throughout a product life cycle. Also, the purpose of providing a summary of a WG discussion is to disclose the details of the discussion, to identify the environmental impact of the concerned product, and to show the types of environmental impact discussed in the Eco Mark program.

3. Other case examples of application of the LCA procedures

3.1 Discussions at review meetings regarding certain issues

In the Eco Mark program, special review meetings may be held upon request by individual WGs or committees in order to assess the environmental impact of certain issues (topics). For example, (1) a review and discussion meeting regarding handling of paper (appropriateness of setting the level of used paper compounding ratio as a certification criterion for paper products) and (2) a review meeting regarding plant-derived plastic and biodegradable plastic (discussion for category assignment) were held recently. Review committees consist mainly of experts and intellectuals from third-party organizations, but those who are from specific industrial fields or consumer groups are also asked to participate. At committees, various discussions are held regarding many aspects, including examination of preceding literature based on LCA data. For example, at the review meeting regarding paper products described in (1) above, the items listed as items to be examined were as follows: /1/ review of environment preservation in terms of paper products, /2/ current status of domestic distribution of used paper pulp, /3/-1 review of the LCA report on domestic paper products, /3/-2 review of the same for overseas, /3/-3 LCA application to paper products based on the report, /4/ current status of sustainable forest certification, and /5/ functional characteristics required for paper products.

3.2 LCA task group activities regarding creation of new product categories

Since FY2005, the Eco Mark Committee for Establishing Category and Criteria conducts preliminary studies based on LCA when discussing whether or not reuse products that are proposed as products of new categories can be newly recognized as products of new categories. For this, as seen in Figure 1, LCA experts are requested for cooperation, and an LCA examination task group is established for examination. Examples of products so far examined are digital printers, filter cartridges for dust masks, and fluid pumps. For the first two products, certification criteria were created based on the report by the task group. For example, in the case of filter cartridges for dust masks, although unwanted [CO_2] is generated while cleaning the filter after repeated use of 10 times, the amount of [CO_2] generated per use is approximately 30% of that of the disposable version.

3.3 Estimation of the environmental preservation effect of some of the Eco Mark products

For Eco-Mark certified ball-point pens, mechanical pencils, marking pens, correction tools, and notebooks, the amount of reduction of environmental burdens in the entire domestic market in FY2001 was estimated[2)]. Environmental burdens were measured for a complete life cycle from raw material collection to disposal and recycling, but the major contribution when calculating the effect was the use of recycled materials that met the Eco-Mark certification criteria. For the four writing materials, compared to non Eco-Mark certified products, the amount of reduced [CO_2] for Eco Mark products was estimated to be approximately 2,600 tons per year in total. As for notebooks, the [CO_2] reduction effect was large when biomass-derived [CO_2] was included, but the amount of generated chemical fuel-derived [CO_2] was actually increased for Eco-Mark certified products.

4. Summary

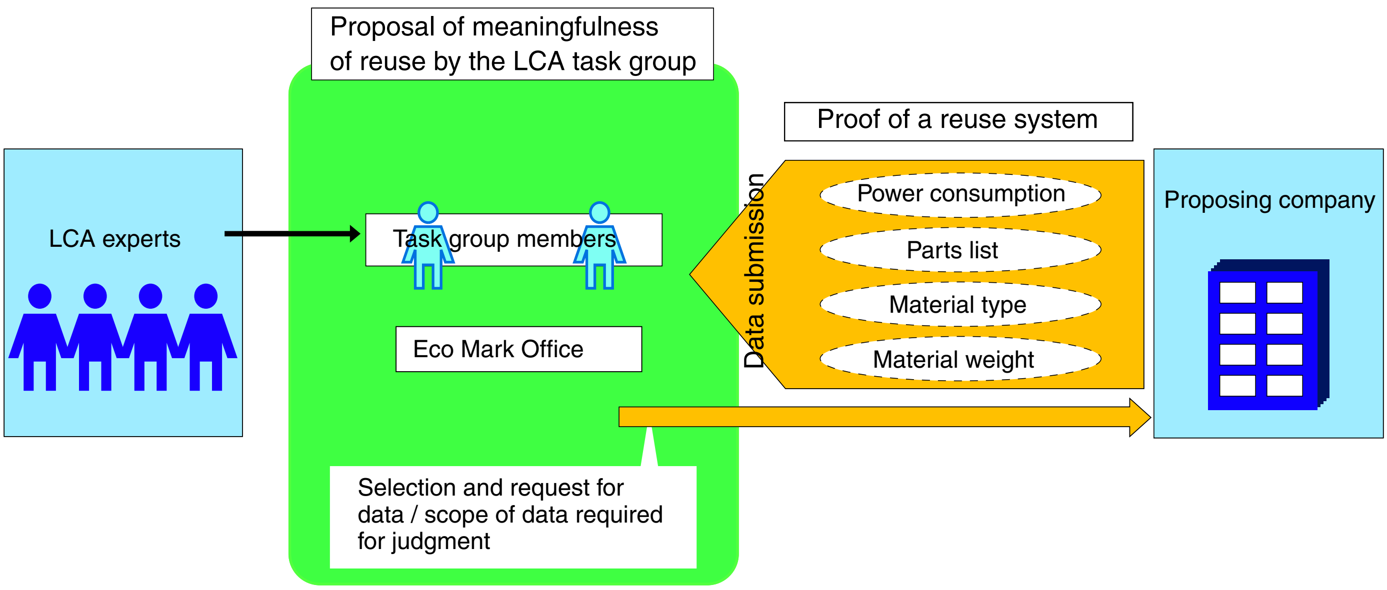
In the Eco Mark program, interested parties participate equally, have discussions and examinations in consideration of environmental burdens on the entire product life cycle, and establish the product certification criteria. The LCA procedures are also used for examination of product categories and for estimation of the amount of reduction of environmental burdens attributed to certification of Eco Mark products.

Reference

1) Environmental Agency Review Committee: "New Development of Environmentally Sound Products" (1995)

2) Japan Environment Association: "Report on Environment Preservation Associated with Eco Mark Certified '5 Types of Stationary' Products" (2005)

Figure 1 Function of the LCA task group and positioning in the Eco Mark project



Outline of the Life Cycle Assessment Society of Japan (JLCA) database

Ryosuke Aoki
Life Cycle Assessment Society of Japan (JLCA)

In Japan, LCA attracted much attention as an effective method to quantitatively evaluate environmental impacts of products and services throughout their life cycles, and in October 1995, the JLCA was established by a large number of intellectuals from industry, government and academia with the JEMAI as the secretariat to actively discuss the methodology, implementation, and advanced application of LCA. In 1997, "The Ideal LCA and Efforts Made by Industrial Sectors" was created as the policy statement. This statement described the current situations and issues regarding LCA method development and suggested as future plans that national level LCA database[1)] development and LCA method development would be necessary[2)]. In accordance with this suggestion, the Ministry of Economy, Trade and Industry organized the LCA national project "Product Life Cycle Environmental Impact Assessment Technology Development (LCA project)" started[3)] from 1998 as a 5-year plan.
The goals of this project were development of the LCA methodology, collection of high-reliability inventory data created by industrial associations, and development of a network system, and research and development was carried out in order to provide a highly-reliable infrastructure for LCA implementation.
In addition to collection of inventory data regarding product manufacturing, and disposal and recycling processes, in the LCA project, characterization coefficients and damage coefficients were developed based on LIME. Based on these achievements, the JLCA has continued data update and addition of new data, and has been operating the database as the domestic LCA infrastructure.
This article will provide an overview of the inventory data stored or disclosed in the JLCA database and a brief explanation about impact assessment data.

1. Inventory data

Data on product manufacturing , and disposal and recycling processes is collected as inventory data, and it is characterized by the fact that, especially for the former, inventory data for major products is voluntarily collected by various product and industrial organizations, or industrial associations, as representative data. As seen in Figure 1, these associations cover a wide range of fields, from extraction of resources to materials manufacturing and assembly industries such as automobiles and others. , and therefore, the data collection instruction manual was prepared so that inventory data could be gathered using a common method wherever possible. The basic principle of this instruction was to collect inventory data of companies belonging to industrial associations and to calculate the average data. Although depending on products, inventory data was collected from various

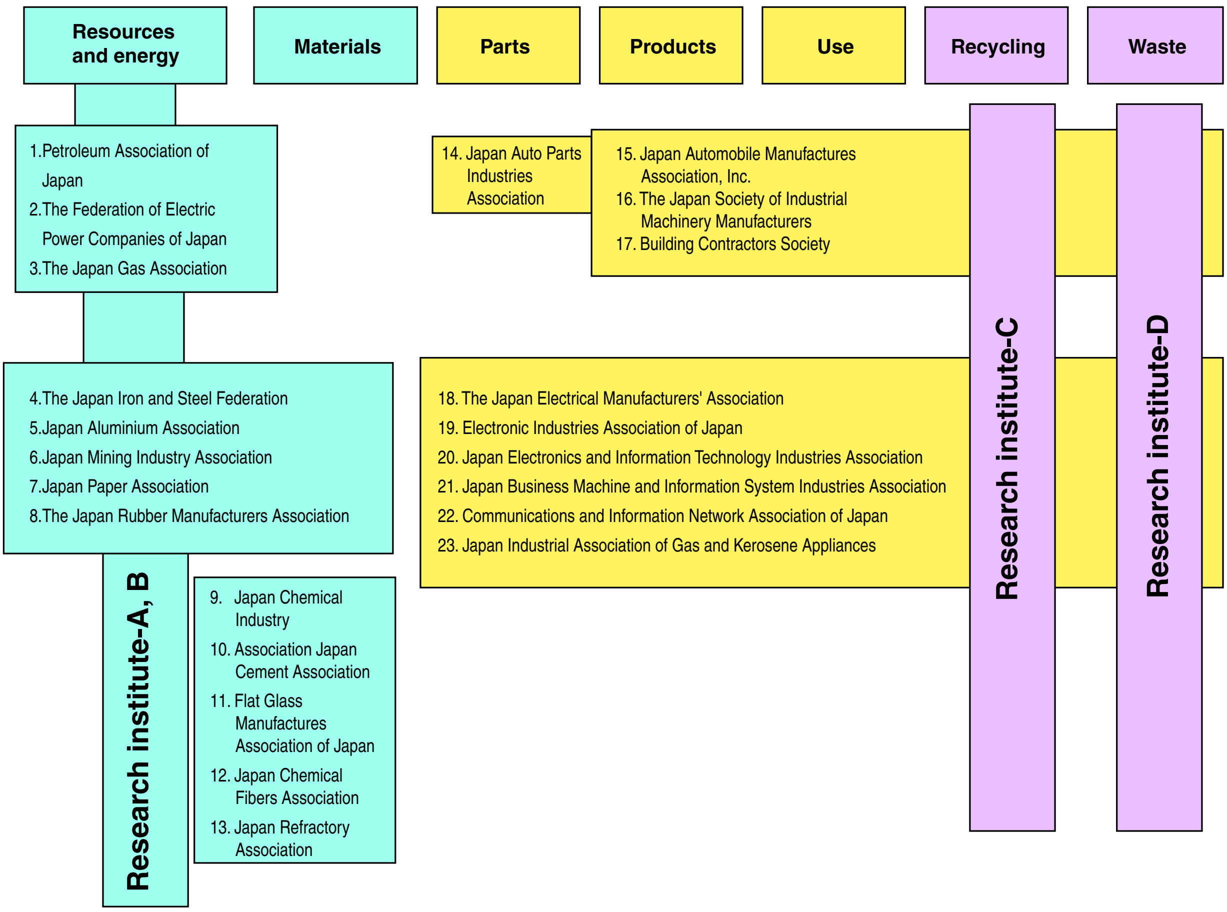


Figure 1 Industrial associations participating in the inventory study group and their responsibilities

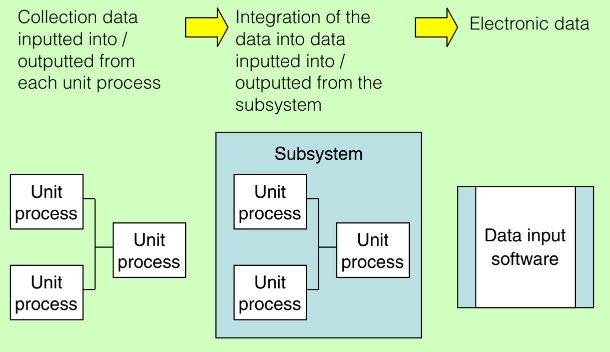


Figure 2 Overall flow of data collection

products collectively accounting for at least 60% of the production share of each product. As a result, highly-reliable background data was collected domestically.

More specifically, as shown in Figure 2, each industrial association compiles input / output data of unit process from its member companies into one block of subsystem data, and voluntarily provides inventory data on product manufacturing as an "integrated database." Each industrial association thus controls its own inventory data system boundaries, and supports "Gate to Gate" to the extent it can be responsible for it. Therefore, there is a fully functional mechanism in which industrial associations can voluntarily update the data at any time.

In the LCA project, 54 industrial associations provided a total of approximately 280 items of subsystem-based inventory data. The target here was to collect data on 14 substances (atmosphere: [CO_2], [CH_4], HFC, PFC, [N_2O], [SF_6], NOx, SOx, and soot and dust; hydrosphere: BOD, COD, total phosphorus, total nitrogen, and suspended solids) as emission items, and as a result of examination of the items by the industrial associations, approximately 70% of emission item data was provided on average.

The JLCA has been publishing data collected from these industrial associations as a database since FY2003, and based on their approval of this voluntary data provision system, the JLCA has also

Table 1 Examples of inventory items collected by industrial association

INDUSTRIAL ASSOCIATION	COLLECTED INVENTORY ITEMS	INDUSTRIAL ASSOCIATION	COLLECTED INVENTORY ITEMS
Petroleum Association of Japan	Crude oil, Bunker A, Bunker C, diesel oil, coal oil, car gasoline, naphtha, and asphalt	Japan Refractory Association	Burnt fire-proof brick, unburned fire-proof brick, refractory product, and castable refractory
The Federation of Electric Power Companies of Japan	Electric power (domestic average, power supply specific, and for daytime or for nighttime)	Japan Auto Parts Industries Association	44 automobile parts
The Japan Gas Association	City gas and LNG	Japan Automobile Manufactures Association, Inc.	1500cc sedan car, standard driving
The Japan Iron and Steel Federation	Shaped steel, thick plate, reinforcing steel, electrogalvanized steel, hot-dip galvanized steel, hot-rolled steel, cold-rolled steel, tin free steel, tin plate, wire rod, special steel, stainless steel, gas pipe (seamless), welded pipe, steel and iron products for building, and coke	Japan Industrial Association of Gas and Kerosene Appliances	SK ovens, SK stoves, gas water heaters, water heaters for baths, gas fan heaters, table-top stoves, hot-water dispensers, oil water heaters, bath tubs with oil water heaters, oil fan heaters, hot-water oil burners, open oil heaters, vent-system oil heaters, and semi-open oil heaters
Japan Aluminium Association	Aluminum extrusion: pipe product; aluminum extrusion: shaped product; aluminum extrusion: rod product; and aluminum plate product	Building Contractors Society	Building (office building of reinforced concrete)
Japan Mining Industry Association	Copper, lead, and zinc	The Japan Electrical Manufacturers' Association	Electric refrigerators
Japan Paper Association	Paper and paper board	Electronic Industries Association of Japan	Color televisions, cathode-ray tubes, printed circuits, LCD devices, passive components, connectors, semiconductors, and converted parts
The Japan Rubber Manufacturers Association	Tires for passenger cars, tires for trucks and buses, and tires for motorcycles	Japanese Electronic Industry Development Association	Notebook PC and desktop PC
Japan Chemical Industry Association	Low-density polyethylene, high-density polyethylene, polypropylene, polystyrene, polyvinylchloride, polyethylene phthalate, and expanded polystyrene	Japan Business Machine and Information System Industries Association	Copy machines
Japan Cement Association	Portland cement, blast furnace cement, fly ash cement, clay, silica, and lime stone	Communications and Information Network Association of Japan	Mobile phones
Flat Glass Manufactures Association of Japan	Glass sheet (including laminated safety glass for automobiles)	The Japan Society of Industrial Machinery Manufacturers	Pumps (typical model) and fans
Japan Chemical Fibers Association	Continuous polyester fiber, and tire cord (nylon and polyester)		

been listing the inventory data provided by these participating industrial associations. Table 1 shows some of the names of these inventory data provided by the industrial associations. Inventory data has been provided from the energy industry fields such as petroleum and electricity, materials industry fields such as iron and steel and plastics, and the assembly field such as automobile.
Furthermore, since the inventory data as a background database provided from the industrial associations has fields with insufficient data, as inventory data that can be shared for various products, data on resource extraction, energy, and transportation, metal and plastic processing stage data, and inventory data on disposal and recycling processes were surveyed and collected independently in the LCA project. The data surveyed contains approximately 300 items.
In particular, data for the following items was collected for the inventory data on waste management and recycling sectors, so called "venous" sector:
/1/ The inventory data on incineration and landfills was created as a product and process-derived environmental burden estimation model based on the analysis of "collection and transportation", "waste composition" and "air pollutant" at the time of incineration by municipalities.
/2/ The inventory data on waste and recycling was created for intermediate processing stages for used cars, home appliances, office automation equipment, and construction waste materials by modeling these processes based on actual measurement data.
/3/ As processes to detoxify materials from landfills at the end of the flow, heavy metal detoxification processes, in which heavy metal is separated from incineration fly ash and collected, were empirically surveyed, and the inventory for the detoxification processing stage through the wet - type (smelting) processing was estimated. The target heavy metals here are Cu, Pb, Zn, Cd, and Hg, and this inventory data will be used as reference data when implementation of the " venous " system LCI is considered and proper evaluation of the steps after landfill is necessary.

2. Impact assessment database

The domestic damage-calculation type impact assessment database developed by the impact evaluation method as part of the LCA project publishes three types of coefficient lists. For development of these lists:

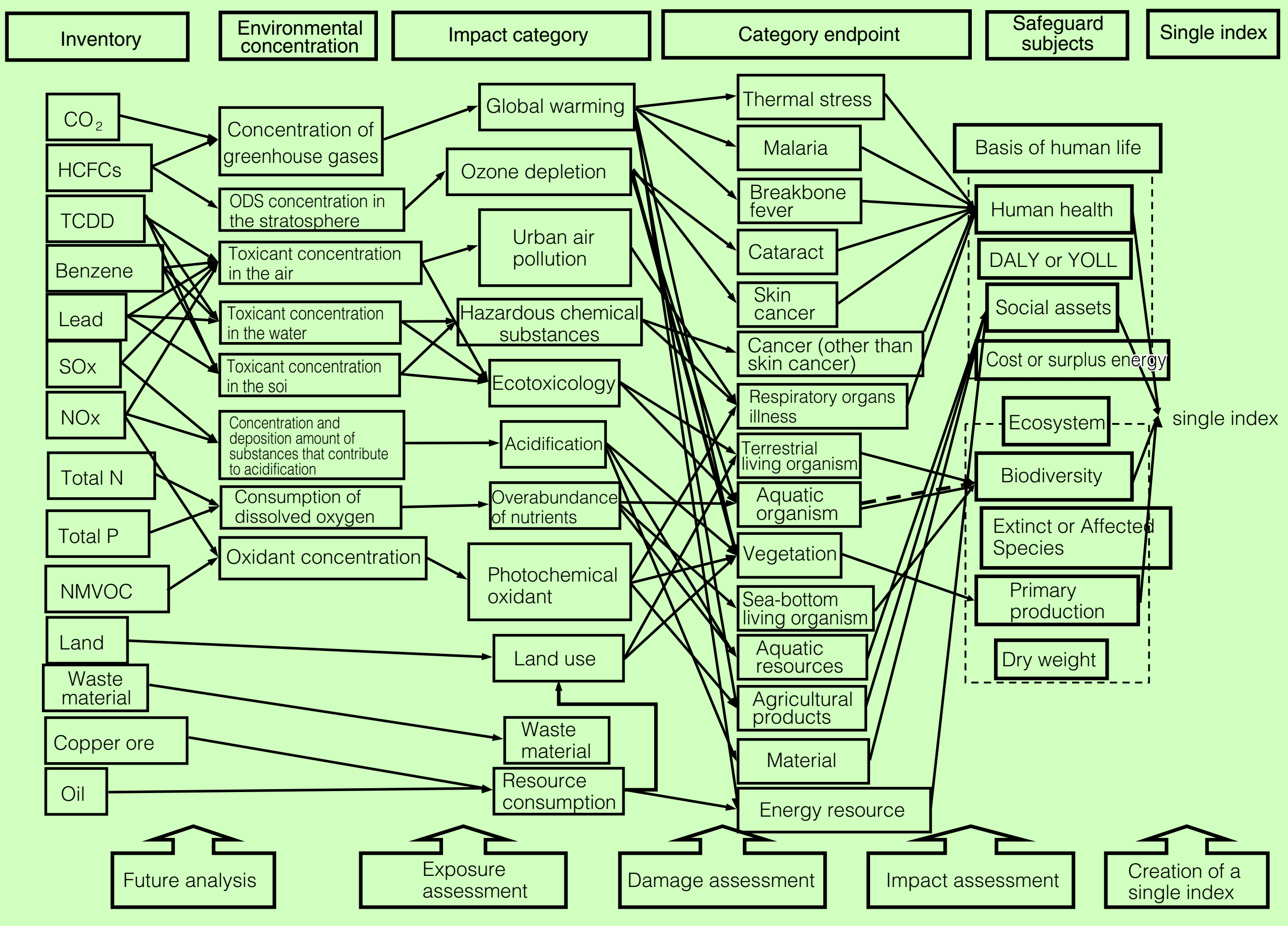


Figure 3 Overview of the damage-calculation type impact assessment system

a. Based on a natural scientific approach to quantitatively evaluate the impact of environmental emission on the environmental categories such as global warming and the amount of the actual damage on the safeguard subjects, the characterization coefficient list for showing the impact on the environmental categories and the damage coefficient list for showing the amount of impact of the actual damage to the aspects to be protected was created.
b. Also, evaluators weighted affected objects that are to be protected, and created an integrated coefficient list based on a social scientific approach for integration.
As a result, the following three coefficient lists were created as the life cycle impact assessment method based on endpoint modeling (LIME), and they are stored in the database and published.
/1/ As the impact category, the characterization coefficient list for 11 items: global warming, ozone depletion, acidification, photochemical oxidant, urban air pollution, hazardous chemical substances, ecotoxicity, eutrophication, land use, resource consumption, and waste.
/2/ The damage coefficient list for four safeguard subjects (human health, biodiversity, primary production, and social assets).
/3/ The integrated coefficient list in which human health, biodiversity, primary production, and the social assets are weighted and made into a single index.
Figure 3 shows the relationships among target impact categories, damage, and safeguard subjects.

3. LCA reference database

For the convenience of those who carry out LCA, LCA reference database is provided together with the inventory and impact assessment database. The reference database provides summary of papers, cited from the case studies at the International Conference on EcoBalance which is held every other year and from LCA research papers mainly about product systems published in major international / domestic academic journals, covering product systems, objective and target of analyses, and analysis methods, with the keyword search function. It is possible to refer to the original papers when carrying out LCA for their own product systems. Currently, there are approximately a thousand registered papers., The JLCA adds and registers more papers every year.

4. Summary

The JLCA has published the LCA database that mainly contains the achievements of the LCA project in which research and development were carried out with the goal of establishing the LCA infrastructure in Japan as a five-year-plan starting since FY1998. This database consists of the "Gate to Gate" inventory data voluntarily provided by industrial associations, the coefficient lists of LIME, and abstracts of LCA references. (Figure 4) After the LCA project, the second term project (FY2003 to FY2005) was implemented in order to further spread the LCA method, and now preparations have been made in order to store various types of inventory data collected during the course of LCA studies on commercial products (vending machines, houses, and ICT devices) and the "venous" system (waste plastic, used home appliances, used car disposal and recycling processes).
An increasing number of companies now understand and recognize the importance of LCA, and accordingly, an increasing number of companies are now using the LCA procedures. At the same time, expectations for the LCA database cover a wider scope. For the future, it is necessary to further improve and enrich data in order to expand the use of the LCA database.

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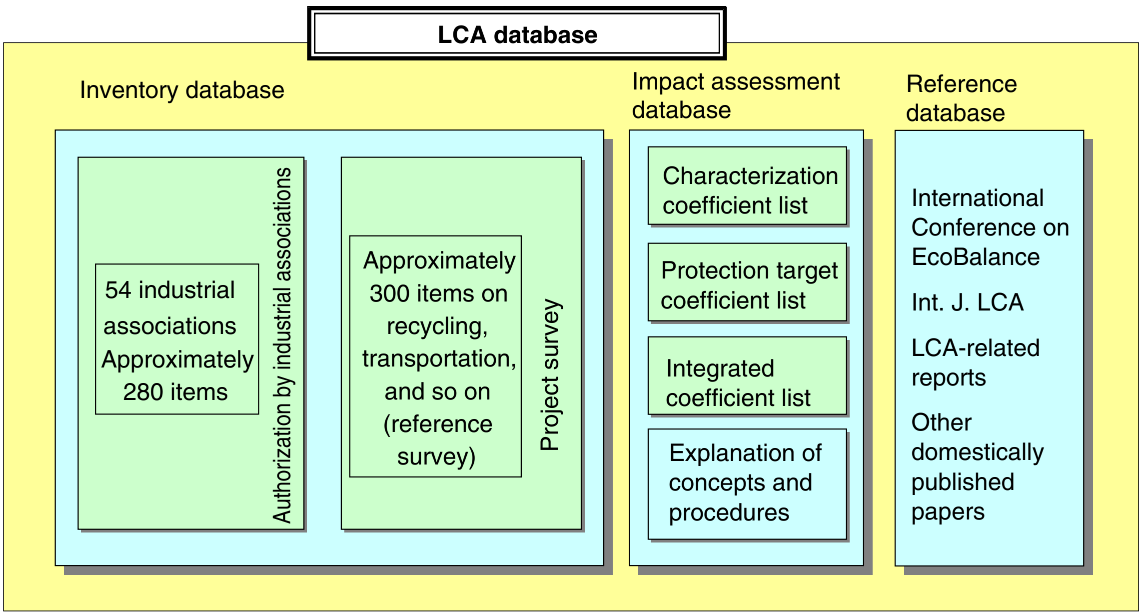

Figure 4 LCA database structure

Review

Environmental Database Based on an Input-Output Table

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1. Introduction

For product designers who are not professionals in LCA (Life Cycle Assessment), life cycle inventory (LCI) analysis is a very time-consuming task, and in order to implement LCI efficiently, a comprehensive environmental database is absolutely essential. With this background, at Toshiba, we have been developing independently an environmental database using the Input-Output table (IO table). Further, the database so built is also being sold to parties outside Toshiba group as an LCA support tool, the Easy-LCA[1]. The IO table of Japan has one of the highest accuracies in the world, and is a very useful data source of LCA. Since the Toshiba group is having a wide range of businesses from household electrical appliances to social infrastructure, the IO table covering the industrial activity in Japan is extremely useful as the common background data within the group. In actuality, the LCA support tool Easy-LCA is being used in various types of industries. In this paper, we present an introduction to the LCA database[2] constructed based on the latest year 2000 IO table. The features of this database are -consideration of environmental loads overseas, expansion of environmental load items that can be calculated, and extension of IO table categories.

2. Features of the IO Table

An advantage of using the IO table is that it is possible to calculate the embodied intensities of environmental load related to all goods and services within the country. There are two known methods of LCI analysis, namely the process analysis method and the input-output analysis method (hereinafter referred to as the IOA method). The process analysis method is the method of calculating the environmental load by collecting and summing the inventory data covering all the processes in the system being evaluated. Theoretically, although the data prepared based on the process analysis method is data with good accuracy and reflects the actual situation, collecting inventory data for all the processes is extremely difficult, and actually the range that can be covered is taken as the defining the boundaries of the system. Therefore, there is no uniformity in the system boundaries of the base unit data prepared by the process analysis method, and the arbitrariness of setting the system boundaries is considered to be problematic. According to the IOA method, all the processes entered in the IO table are covered, and the system boundaries in embodied intensities of environmental load of all goods and services will be identical. In addition, by constituting the embodied intensities of environmental load of each and every good and service, since it is possible to restrict to the minimum amount necessary the inventory data to be collected at the time of implementing LCA, the labor and cost of conducting LCA can be reduced.

3. Features of the Database

3.1 Environmental Load Overseas

On the other hand, even the IOA method is not omnipotent, and requires care in handling the environmental load abroad. While the IO table is a matrix that covers all the industries inside Japan, the production processes of imported materials is outside the target range. The percentage of import of natural resources is particularly high in Japan and almost all natural resources are imported, and the production technologies and industrial structures of the countries producing the natural resources, etc., is largely different from that of Japan. Therefore, the probability is very high that the embodied intensities of environmental load calculated using a model limiting the evaluation scope to within Japan (the non-competitive import type model) or the model assuming that all imported goods are produced within Japan (the competitive import type model) are far separated from the actuality.

The above problem is interpreted as a problem of the system boundaries in LCA. In this database, a hybrid method of the process analysis method and the IOA method is used for the handling of imported goods. So far, a method has been proposed[3] of calculating the environmental loads related to the mining process and the transportation process abroad based on the process analysis method, and adding to the environmental load within Japan based on the IOA method. This method has the feature that it handles in detail only a specific imported goods. Since it is impossible at present to consider the processes abroad for all imported goods, the embodied intensities are obtained by the process analysis method in detail only for the imported goods that have a large effect, and the environmental load is calculated assuming to be manufactured inside Japan for all other imported goods. In this database, based on the above method, the environmental loads overseas are obtained by the process analysis method for aluminum ingot, iron ore, copper ore, lead ore, zinc ore, coking coal, steam coal, crude oil, LNG, and LPG, and were added to the environmental load within Japan. Due to the restrictions on the data, the overseas environmental loads take energy consumption, CO_2, SOx, and NOx as the targets.

3.2 Target Environmental Load Items

Table 1 shows the environmental load items that are the target of this database. In a large number of LCA evaluation examples that used the IOA method so far, the attention is focused on the amount of energy consumption and the amount of CO_2 emission as the environmental loads. While these two are the typical indices, they only take one aspect of the environmental loads. This database takes as the target a total of 30 types of environmental loads including the amount of energy consumption and the amount of CO_2 emission (Table 1). The extension of the inventory items leads to aggregation of environmental impacts due to the life cycle impact assessment method (LCIA). In recent years, because a Japanese version of the endpoint type of LCIA method[4] has been developed, it has become possible to integrate various types of environmental loads, and to evaluate as a single index. If LCIA is to be implemented, it is advantageous if there are a large number of inventory items that can be calculated.

Table 1 List of inventory items in the environmental database

Category		Item
Output	Atmosphere (8 categories)	CO_2, SO_X, NO_X, PM, HFC, HFC23, PFC, SF_6
	Hydrosphere (5 categories)	BOD, COD, SS,T-N, T-P
Input	Energy (3 categories)	Crude oil (fuel), coal, natural gas
	Resource (13 categories)	Crude oil (raw material), iron,copper, aluminum, lead, zinc, manganese,nickel,chromium, sand, rock limestone, wood
Energy (1 category)		Energy consumption (amount of heat generated)

3.3 Extension of IO Classifications

The IO table is a matrix that consolidates various goods and services into about 400 sectors, and since each sector is composed of several goods, the embodied intensities of environmental loads based on the IO table is calculated as an average value of several goods. In cases in which the emission source is only due to a specific good included in a particular IO sector, the embodied intensity of environmental load with a large error is calculated, and hence there will occur allocation errors.

In this database, in order to improve the accuracy of the embodied intensities of environmental loads, the IO sectors have been further subdivided. In the current IO sector classifications, although the sectors whose amounts of use or market sizes are small are not prepared as independent IO sector classifications, by making them into a sector it is possible to handle clearly the goods having a large environmental impact even if their amount of use is small. In this database, in order to increase the accuracy of the embodied emission intensities of greenhouse gases (GHG), the related IO sector classifications were subdivided further independently. Although the IO sectors is aggregated to 399 sectors by making the square matrix, based on the above thinking, by subdividing the IO sectors related to GHG emission, these have been expanded to 405 sectors. In addition, regarding the subdivided GHG related IO sectors, by limiting the destinations of their input to sectors related to GHG emission it is possible to calculate the accurate embodied intensities of environmental load. Further, as a rule, the subdivision of IO sector classifications is based on the proportion of amounts of money. Correcting data of each GHG production process using the process analysis method further increases the accuracy.

Further, the embodied intensities calculated from the IO table are the amount of environmental load per unit money amount, and is constituted of 405 sectors . By using the unit price of the good and service given in the IO table[5)] it is possible to calculate the embodied intensities of environmental load in physical units. In this database, based on this thinking, about 4000 types of embodied intensities are being prepared.

4. Data Sources

Although the method of calculating the embodied intensities of environmental load based on the IO table is described in more detail in other literature[6)], the estimation of the environmental load generated directly in each IO sector classification is the most important one. In this database, the amounts of environmental loads for each IO sector classification are being estimated by combining various types of statistics shown in Table 2.

Table 2 Data sources for the environmental database

Data		Sources
Energy and resource consumption		IO Table (IO table on values and quantities)[7],Yearbook of Minerals and Non-ferrous metals statistics 2000[8],others
Emissons to atmosphere	Energy consumption(as a fuel)	IO Table (IO table on values and quantities)[7],Yearbook of Minerals and Non-ferrous metals statistics[8], The Structural Survey of Energy Consumption in Commerce and Manufacturing[9]
	Emission coefficients	Ministry of Environment[10], others
	Emissions outside Japan	IEA[11], others
Emissions to hydrosphere		Ministry of Environment[12], others

5. Conclusion

In this paper, we have introduced the environmental database based on IO table developed by Toshiba. At the present time, this database is of the largest size in terms of the number of embodied intensities and the number of environmental load items as an environmental database based on the IO table of the year 2000. The environmental database based on IO table is very useful from the point of view of uniformity of data and reducing the labor involved in implementing LCI, and by carrying out the modifications mentioned above, the usefulness of the IO table is considered to become still more enhanced. However, the environmental database based on IO table will have to be used, supposing their uncertainties. In recent years, although the hybrid method that combines the process analysis method and the IOA method is attracting a lot of attention, the accuracy of LCA result gets improved by a large amount by using the IO table data as only background data and by collecting the accurate foreground data of the target system of evaluation. It is hoped that this paper is helpful in understanding IO table database.

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AIST-LCA Database

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1. Introduction

The LCA (Life Cycle Assessment) procedure is now widely known and used as one of the methods to evaluate environmental compatibility of products. As the LCA develops, the necessity for further advanced analysis increases, and therefore, an increase in the volume of data for the background database and elaboration of data are required. For this reason, we developed chemical product inventory data from the process analysis data, and also developed iron-and-steel product inventory data from iron-and-steel-related statistical data. In addition, we collected inventory data regarding waste disposal from various papers, reports, and interviews, and summarized it as a background database. These data can be analyzed by AIST-LCA Ver.4 (JEMAI-LCA Pro), and part of the data belongs to studies outsourced by the Japan Environmental Management Association for Industry (JEMAI). This article provides an overview of how to develop data for individual databases. Refer to the optional data package available from JEMAI.

2. Chemical products

This database contains chemical products that are mainly associated with resin products. As seen in Table 2-1, resin products refer to 54 kinds of resins and rubber products. When semi-manufactured chemical products and basic chemical products that are necessary for producing the resin products mentioned above are added, a total of 313 products constitute the inventory database.

Many of the chemical plants that produce these products simultaneously generate both electric power and steam to efficiently provide energy for various processes. In the conventional database, however, the amount of electric power used is represented as system power data, and the amount of steam used is represented as heavy oil boiler data. In order to carry out more accurate analysis, it is necessary to take in-house power generation into account. Therefore, in order to take in-house power generation at chemical plants into account, we estimated environmental burdens of electric power and steam by using statistical data. Also, we developed chemical product background inventory data while taking into account the burdens associated with processing of emission, which is obtained from process analysis data.

Table 2-1 Chemical product list

ABS (flame-proof)	Poly urethane (foamed)	Polyvinyl chloride emulsion
ABS resin	Polyether polyol	Methacrylic resin
[r] butyl ether melamine resin	Polyester polyol	Melamine resin (syrup)
MBS resin	Polyethylene terephthalate PET	Vinylidene chloride resin
n-butyl ether melamine resin	Polyol	High-density polyethylene (HDPE)
Ionomer resin	Polycarbonate	Linear low-density polyethylene
Acrylonitrile styrene resin	Polystyrene (general purpose)	Low-density polyethylene
Ethylene methacrylic acid copolymer	Polystyrene (impact-resistant)	Urea resin (syrup 65%)
Ethylene-vinyl acetate copolymer	Polystyrene (flame-proof)	Expanded polystyrene (EPS)
Epoxy resin	Polytetrafluoroethylene	Unsaturated polyester resin (dissolution and polymerization)
Nylon 6	Polyvinyl alcohol	Denatured PPO
Nylon 66 (fiber)	Polyphenylene ether resin	Polyacrylonitrile fiber
Phenol resin	Polyphenylene sulfide	Carbon fiber (PAN system)
Hexane copolymer	Polybutylene terephthalate	Carbon fiber (pitch system)
Polyacrylonitrile	Polybutene-1	Ethylene-propylene-diene terpolymer
Poly acetal	Polypropylene	Butadiene rubber latex
Polyimide	Polymethylpentene	Butyl rubber
Polyurethane (flexible)	Polyvinyl chloride	Polybutadiene

2.1 How to develop data

2.1.1 In-house power generation

To consider in-house power generation, it is first necessary to obtain the ratio of the amount of in-house power generation with respect to the amount of power consumption as well as the amount of energy consumption for each type of energy associated with steam production. It is also necessary to allocate the steam produced by boilers to the purposes of in-house power generation and production processes. In this database, the steam volume for both in-house power generation and for production processes is obtained based on the statistical values provided for industry categories corresponding to individual products. For this, it is necessary to know the volume of fuel consumption, in-house steam-power generation, and volume of steam for individual industry category subtypes, and the industrial statistics "FY2000 The Structural Survey of Energy Consumption in Commerce and Manufacturing (commerce and industry) 1" published by the Ministry of Economy, Trade and Industry provides data on energy type-specific consumption volume for individual industry category subtypes. The "FY2000 Yearbook of the Current Survey of Energy Consumption 2" provides the amount of steam consumed for in-house power generation, production processes, and other reasons in eight business categories corresponding to intermediate industry categories. By effectively using the above-mentioned statistical data, we obtained the amount of energy used for in-house power generation and steam production for individual industry category subtypes, and then calculated their respective environmental burdens.

2.1.2 Handling of discharge

Discharge from chemical product manufacturing processes may be gas, fluid, or solid, and depending on the form, various types of handling are applied as shown in Table 2.

For the processing method with the "[O]" symbol, we developed a discharge processing calculation program to develop data for each process. Data have not been developed for other processing methods as no particular processing is required or discharge is processed where it is used. A waste gas incineration tower and an incinerator directly burn waste gases, waste fluids, and solid substances at a high temperature, while in catalytic combustion waste materials are burned at a low temperature by using a catalyst instead of flames. In both cases, the amount of discharge was calculated based on the amount of flammable carbon,

Table 2-2 Types of discharge handling

Form	Processing		
Gas	Vent (no processing)	Non-toxic gas (CO_2,$N_2$$H_2O$,and so on), air emission	
	Waste gas incineration tower	When the gas is flammable and the combustion gas not toxi	
	Incinerator	When post-combustion removal processing is neccesary	
	Catalytic combustion	To burna small amount of flammable materials contained in the waste gas	
	Use as fuel		
Waste fluid	Incinerator	Flammable waste fluid	
	Use as fuel		
	Valuable resource collection		
Wastewater	Pretreatment	Filtration, neutalization, and static separation	
	Activated sludge treatment	Discharge treated water, and incinerate waste sludge	
Solid	Regeneration	Dgradation cataryst	
	Incinerator	Flammable solid substancess, detoxification if neccessary	
	Disposal	Waste catalyst, waste absorbent, waste plaster, sulfate iron, and so on	
	Aqueous dissolution (wastewater treatmen)	Waste salt	

hydrogen, and sulfur contained in the discharge to be processed (burned) and the fuel. The amount of nitrogen was not used in the calculation since products change in a complicated way depending on combustion conditions. As for the wastewater treatment, the activated sludge treatment is carried out after a pretreatment such as dissolution, neutralization, static separation, and filtration. At a chemical plant, instead of treating each type of generated wastewater separately, all types of wastewater that can be treated by the activated sludge treatment are collected in one activated sludge treatment facility and then treated. After these wastewaters flow into the activated sludge treatment facility, they are mixed and diluted to make their concentration adjusted to the BOD (or COD) concentration which is suitable for the activated sludge treatment. The amount of agents and power consumed change proportionally with the amount of wastewater in some cases, while in other cases, the amount of agents and power consumed change proportionally with burdens. Therefore, we considered that the power and agent to be used in the activated sludge treatment of wastewaters (from manufacturing plants and chemical products) should be distributed based on the BOD loading and the amount of processing of wastewaters treated at the activated sludge treatment facility. In this study, based on the assumption that a standard activated sludge treatment facility is capable of processing 300 m3/h at the BOD concentration of 500 mg/l (BOD loading of 150 kg/h), we obtained from the BOD loading and the volume processing the amount of power and agent consumed used in the processing of various types of wastewaters. Through the procedures described above, we developed the database by adding environmental burdens associated with discharge treatment to the aspect of manufacturing of chemical products.

2.2 Summary

As described above, we first obtained input and output data through process analysis and developed an inventory in which in-house power generation is taken into consideration in terms of input of electric power and steam, and in which discharge treatment is taken into consideration in terms of discharge. This database covers more than 90% of the resin product manufacturing volume; therefore, it can be concluded that data are available for all general-purpose products.

3. Iron-and-steel products

Various types of statistical data mainly from the year 2000 were used in developion of iron-and-steel material inventory data, and we calculated and tabulated the inventory in accordance with the

Table 3-1 Iron-and-steel product list

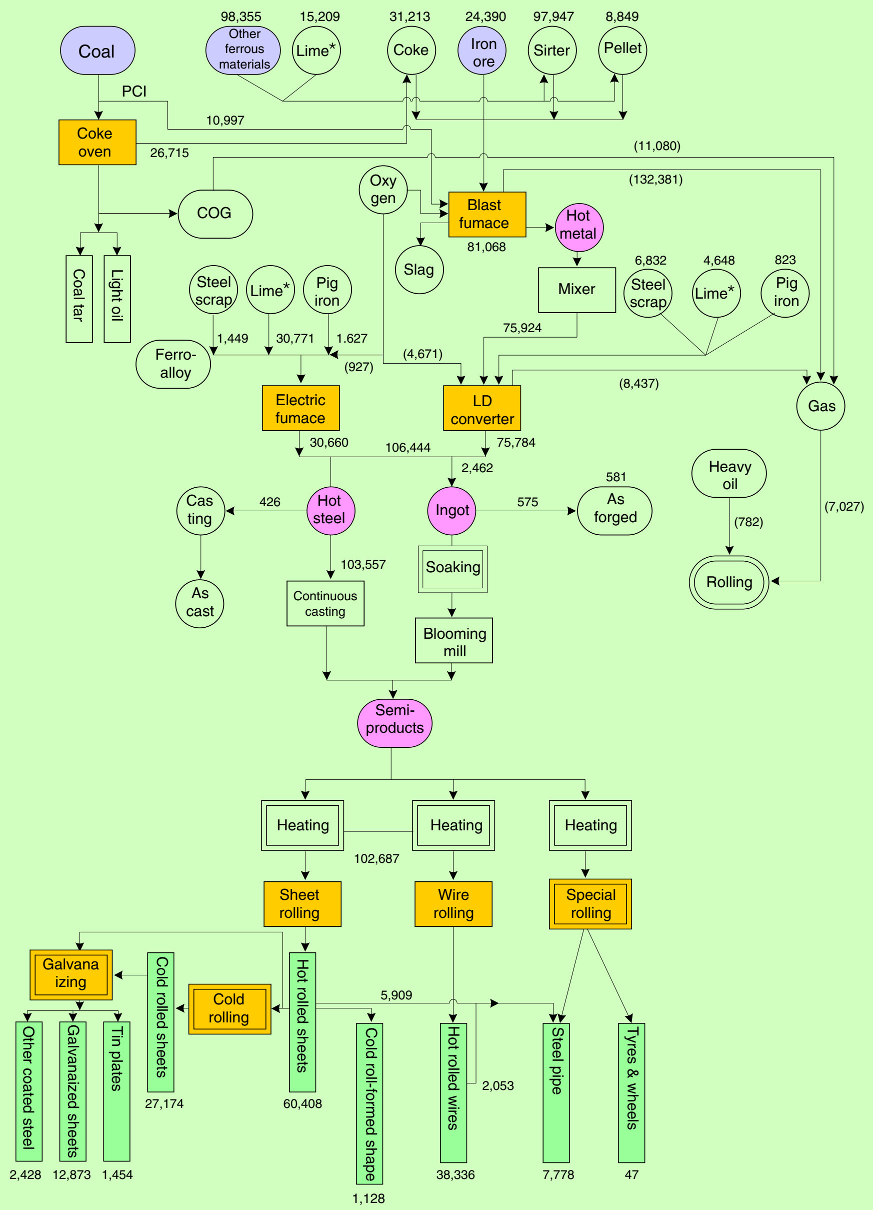
Ferromanganese	Common steel: wire rod (electric furnace)	Special steel: sheet pipe (electric furnace)
Silicon-Manganese	Common steel: medium thick plate	Electric steel sheet
Ferrosilicon	Common steel: hot-rolled steel	Surface-treated steel sheet
Ferro chrome	Common steel: cold-rolled steel	Tinned steel sheet (tin plates)
Ferronickel	Common steel: steel pipe	Tin-free steel
Ferromolybdenum	Special steel: shaped steel	Galvanized steel sheet
Ferrovanadium	Special steel: shaped steel (converter)	Tool steel
Ferrotungsten	Special steel: shaped steel (electric furance)	Carbon steel for structural use
Coke	Special steel: bar steel	Alloy steel for structural use
Sinteredore	Special steel: bar steel (converter)	Spring steel : ball-bearing steel
Pellet	Special steel: bar steel (electric furance)	Free-cutting steel
Pig iron (blast fumance)	Special steel: wire rod	Hig-tensile steel
Foundry pig iron	Special steel: wire rod (converter)	Stainless steel : shaped steel
Crude steel (converter)	Special steel: wire rod (electric furance)	Stainless steel : bar rod
Crude steel (electric furnace)	Special steel: thick plate	Stainless steel : wire rod
Common steel:shaped steel	Special steel: thick plate (converter)	Stainless steel : medium thick plate
Common steel:shaped steel(converter)	Special steel: thick plate (electric furance)	Stainless steel : hot-rolled steel
Common steel:shaped steel (electric furnace)	Special steel: hot-rolled steel	Stainless steel (austenite series): hot-rolled steel
Common steel:bar steel	Special steel: hot-rolled steel (converter)	Stainless steel (ferrite series): hot-rolled steel
Common steel:bar steel (converter)	Special steel: hot-rolled steel (electric furance)	Stainless steel: cold-rolled steel
Common steel:shaped steel (electric furnace)	Special steel: cold-rolled steel	Stainless steel (austenite series): cold-rolled steel
Common steel:wire rod	Special steel: steel pipe	Stainless steel (ferrite series): cold-rolled steel
Common steel:wire rod (converter)	Special steel: steel pipe (converter)	Stainless steel: steel pipe

iron-and-steel manufacturing process. Table 3-1 shows the inventory data. The inventory is divided into 69 products such that data for converter steel, electric furnace steel, and their average values can be examined.

3.1 How to develop data

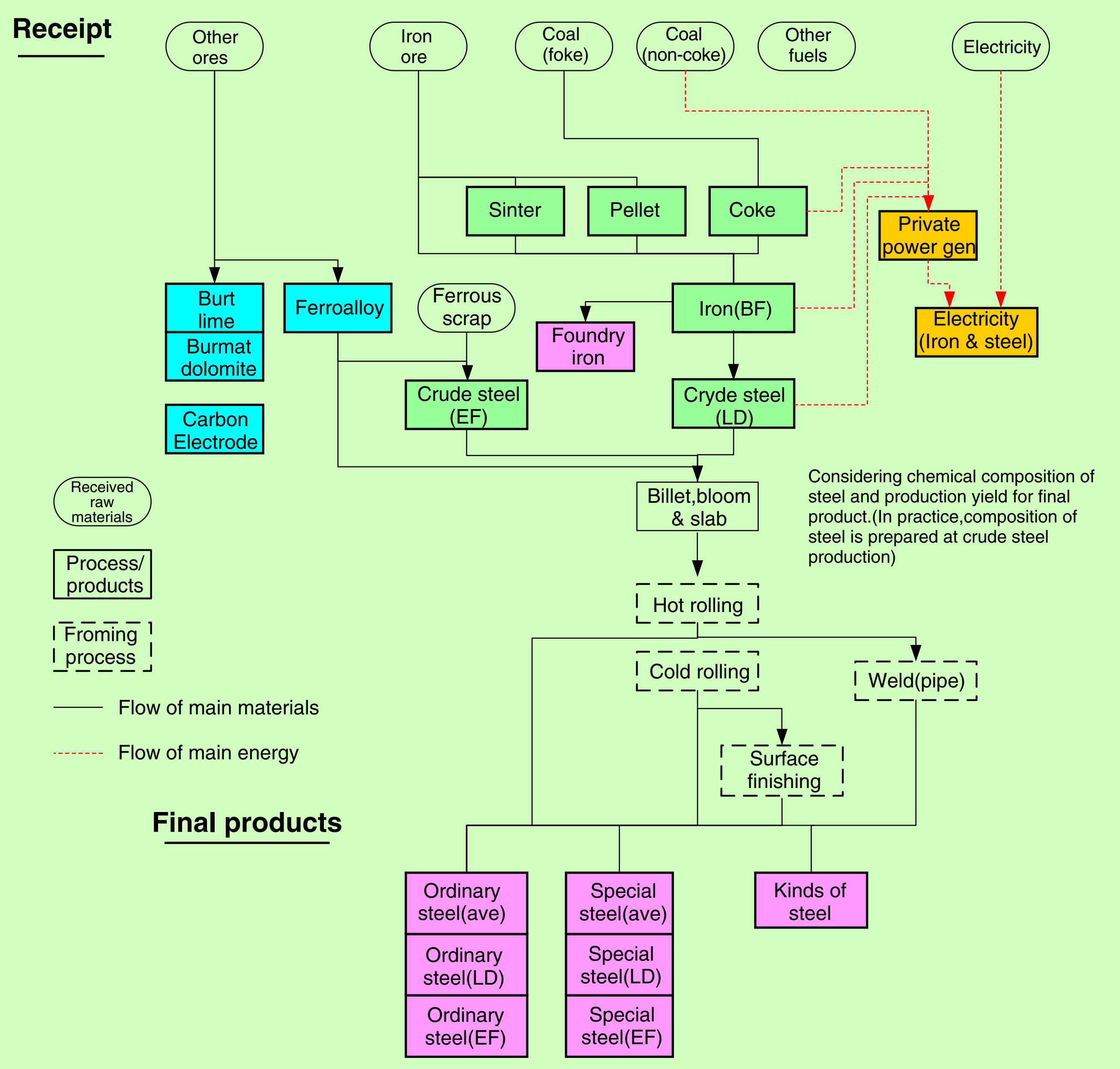
We used mainly the FY2000 Yearbook of Iron and Steel Statistics to develop the iron-and-steel product inventory. This yearbook has sections where it cites other statistical materials (the Yearbook of Mining, Non-Ferrous Metals, and Product Statistics, tables in the Current Survey of Energy Consumption, and so on), and the values contained in the cited data were used when developing data.
Also, values developed based on the calendar year (January to December, 2000) were prioritized over the fiscal year. The Yearbook of Iron and Steel Statistics is based on the Current Survey of Iron-and-steel Production and the Current Survey of Energy Consumption. In the Current Survey of Iron-and-steel Production, the major sellers of common steel and all companies that can be categorized as suppliers of pig iron, ferroalloy, crude steel, forged steel, cast steel, hot-rolled steel products, cold-finish steel products, coated steel, cold-roll formed steel, steel pipe, steel processed products, or cast-iron pipe are all investigated. Based on the statistical data, the iron-and-steel production process and the list of production volume for FY2000 are shown in Figure 3-1.
Since the inventory is based on statistical data, the system boundaries are set at acceptance of raw fuel in the steel industry

Figure 3-1 Iron and steel production process (the Handbook for Iron and Steel Statistics 2001)



and at shipment of final steel products as seen in Figure 3-2. As subsystems, areas surrounded by thick lines are the processes and products, and areas surrounded by dotted lines are processing stages for which the inventory is developed. The solid lines show the flow of main raw materials, and dotted lines show the flow of major energy related to electric power. The components of steel products are adjusted by ferroalloys at the time of crude steel manufacture in a converter or electric furnace, but this is not incorporated into the crude steel inventory. Therefore, in order to incorporate the component composition of the final steel products into the crude steel inventory, we reviewed the product yield as slabs and set the amount of ferroalloy in accordance with the component composition and also the amount of required crude steel (converter / electric furnace).

Figure 3-2 System boundaries and subject products / processes



We developed the data by applying assumptions to the conditions and individual processes shown above such that they would match with the actual processes. More specifically, we developed data by dividing the total volume of material data and fuel data inputted into each process contained in the statistics by the production volume to obtain the input volume per kilogram. The data incorporates joint thermal power and in-house power generation, too. For development of individual inventories, refer to the instruction manual of the optional data package.

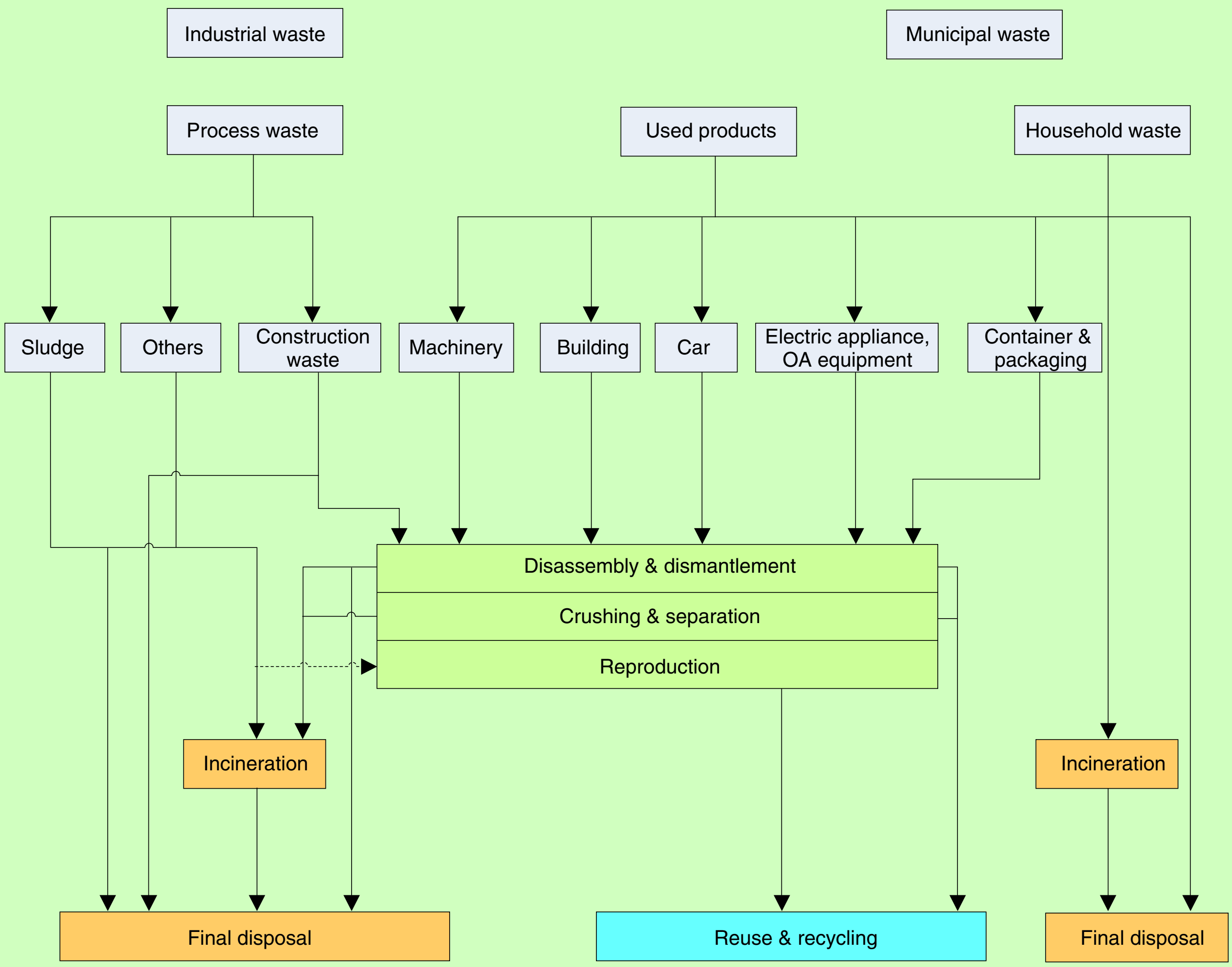
3.2 Summary

As described above, we developed the inventory based on iron-and-steel-related statistical data. Only the burdens associated mainly with energy consumption are calculated as discharge burdens in this inventory data. Some data, such as dissolution and manufacturing methods (converter steel, electronic furnace steel) and component composition, was developed based on estimates; therefore, data must be applied with caution. For more precise LAC, it is possible to use PRTR which is similar statistical data.

4. Waste disposal technology

The disposal and recycling inventory is not fully developed.
As shown in Figure 4-1, there is quite a wide variety of types of subject waste such as process waste, used products, and waste generated in daily living, and their handling can be roughly divided into waste disposal as final disposal by means of incineration or landfill, and into recycling and reuse by means of scrapping, sorting, or reproduction.
Waste disposal involves a few kinds of processing and

Figure 4-1 Schematic diagram of the disposal and recycling flow



Transportation between processes are not shown.

transportation before the final disposal stage, but all the flows are in the same direction and handling of data does not therefore cause any problems. Recycling on the other hand can be in various styles, and handling of data is not simple in terms of LCA due to distribution problems. More specifically, it is necessary to clarify how to allocate environmental burdens to outputs to be recycled in order to avoid complications. The software (AIST-LCA Ver.4 / JEMAI-LCA Pro) is designed to handle these outputs as by-product materials, by-products, or by-product utilities. Contrary to the product system (the "arterial" system; flow from raw material development to production, distribution, and consumption), recycling of used products (the "venous" system; flow from disposal to collection and recycling) has a diverging data structure that is made into a wide variety of outputted products (outputs), and the volume and quality of the products largely depend on quality of used products to be deployed. Also, types of recycling of used product, as shown in Figure 4-2, are different between containers and packages, and assembled products such as machinery, buildings, cars, and home appliances. Since assembled products (consumer durable goods) often consist of a large number of parts and materials, except for the case of reuse, these products cannot be considered as materials unless they are dismantled, scrapped, crushed, or sorted. Meanwhile, containers and packages have simpler structures than assembled products, and they can be considered as materials after separation and sorting only. These materials can therefore be considered as raw materials.

4.1. Approach to data development

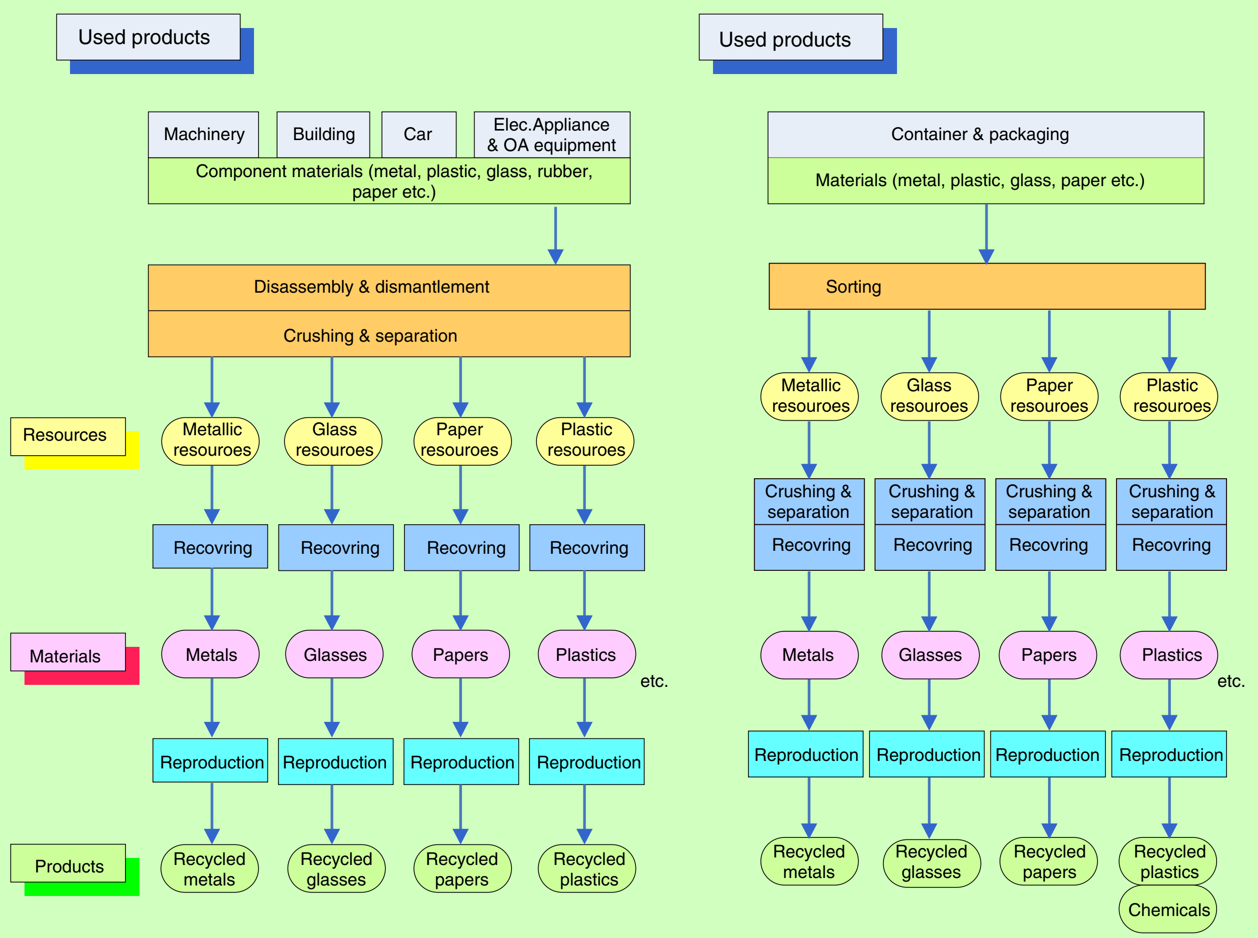
This waste-related data package is developed based on the following assumptions.

<Assumptions>

/1/ Disposal and recycling process is considered as disposal (Ds).

/2/ Among outputs (recycled items) generated in the disposal and recycling process, by-product raw materials that do not cause environmental burdens will be considered as raw materials.

Figure 4-2 Used product recycling flow



/3/ Recycling using recycled raw materials is considered as production (Pd).
/4/ Among outputs (recycled items) generated in the disposal and recycling process, those that can substitute for the existing products are considered as by-products, and the substitution rate must be set. Environmental burdens are to be deducted.
/5/ Among outputs (recycled items) generated in the disposal and recycling process, utilities are considered as by-product utilities, and the subject utilities and their substitution rates must be set. Environmental burdens are to be deducted.

In /1/, the software is designed such that products are not included as outputs, and process outputs are registered as by-product raw materials, by-products, or by-product utilities. /2/ has been mentioned for the convenience of software data processing, and process outputs are treated in the standard flow in the same manner as resources. The quality of outputs of intermediate processing stages greatly vary and may need further processing. In this data package, the outputs are treated as by-product raw materials from the intermediate processing stages. Therefore, when necessary, in using by-product raw materials, environmental burdens have to be taken into account. (examples: sizing and sorting by scrap shops, and cleaning and improving of collected parts). In /3/, many recycling processes share common methods and handling with manufacturing using new raw materials, and outputs (recycled products) are often handled as products; therefore, this recycling processing is considered as production (Pd). When there are by-products, they can be used in allocation (example: manufacturing of recycled PET flakes). The item /4/ is applied in the case where applications of the process outputs and substances to be substituted are certain, and where environmental burdens of the relevant substances, not by-product raw materials, are expected to be deducted (example: evaluate and deduct steel scrap as accounting for 90% of crude steel). In /5/, by-product utilities such as collected electricity and collected steam can be treated in the same manner as /4/ above.

Since the waste and recycling related inventory changes with quality of the subject waste and used products, it is difficult to organize it as a general-purpose process. Therefore, in this data pack, the inventory is considered as energy, sub-resources, and environmental burdens that are directly involved with the waste and recycling processing, and environmental burdens and outputs that are derived from inputs (waste, used products, and so on) are not shown. This must be kept in mind when using the inventory even though there are some examples that show typical values and mean values. The functional unit of the inventory in principle is 1 kg of inputs for the disposal processing (Ds) and 1 kg of products for manufacturing processing (Pd) such as recycling process.

4.2 Summary

Based on the ideas introduced above, a total of 83 types of inventory data now exist as shown in Table 4-1, consisting of reference data and data collected through interviews.

Table 4-1 Disposal and recycling related data

RDF fluff PWMI	Disposal, waste shaft furnace gasification and fusion NEDO	Disposal, car inermadiate processing NEDO
RDF pellet PWMI	Disposal, waste incineration (stoker-fired furnace) ash fusion NEDO	Disposal, incineration ash fusion (electric) NEDO
RPF (otherplastics)	Disposal, waste incineration (plastic PET) NRI	Disposal, incineration ash fusion (fuel) NEDO
Recycled PET flakes	Disposal, waste incineration (plastic PO) NRI	Disposal, incineration processing (general wasted) NEDO
Recycled PET flakes (CPBR)	Disposal, waste incineration (plastic PS) NRI	Disposal, incineration processing (wasted plastics) NEDO
Recycled PET resin (for bottles), CR	Disposal, waste incineration (paper) NRI	Disposal, food scrap composting (centraized system)
Recycled PET resin (for fiber), CR	Disposal, waste incineration (fluidized-bed) ash fusion (electric)	Disposal, food scrap composting (distributed system)
Recycled PO fluff	Disposal, waste incineration processing NRI	Disposal, food scrap disposer processing
Recycled PO pellet	Disposal, waste incineration and power genaration (stoker-fired furnace)	Disposal, food scrap methane fermentation (centrized system)
Recycled PSP tray (lamineted)	Disposal, waste incineration and power genaration, ash fusion (electric)	Disposal, simple incineration (waste plastic) ASIT
Recycled PS pellet	Disposal, waste incineration and power genaration, ash fusion (fuel)	Disposal, simple incineration (waste plastic) PWMI
Recycled PS pellet (colored)	Disposal, waste direct fusion NEDO	Disposal, intermediate processing (metal can glass bottle manual sorting)

Table 4-1 Disposal and recycling related data

Recycled PVC gl ash PWMI	Disposal. waste fluidized-bed furnace gasification and fusion	Disposal. intemediate processing (metal can, glass bottle: sorting)
Recycled PVC crushed item (course crushing) VEC	Disposal. waste fluidized-bed furnace gasification and fusion NEDO	Disposal. intemediate processing (mixed metal can: sortingusing magnet)
Recycled PVC crushed item (fine grinding) VEC	Disposal. super market waste power ganeration NEDO	Disposal. landfill processing (shredded metal)
Recycled PVC pipe VEC	Disposal. chlorofluorocarbon destruction processing NEDO	Disposal. landfill processing (general waste) NEDO
Recycled PVC-containing plastic desalination RPF pellet	Disposal. home appliances advvanced intermediate processingNEDO	Disposal. landfill processing (weste plastic) NEDO
Recycled PVC floor material m2 VEC	Disposal. home appliances advvanced intermediate processing (crushing and sorting) NEDO	Disposal. landfill processing (general weste) PWMI
Recycled PVC floor material VEC	Disposal. home appliances advvanced intermediate processing (crushing and dismantling) NEDO	Disposal. landfill processing (non-combustible residue) NEDO
Recycled used paper pulp (paper container) NRI	Disposal. home appliances intermediate processing NEDO	Wastewater treatment (industrial wastewater)
Recycled plywood panel	Disposal. building site dismantling NEDO	Sewage processing NEDO
Recycled white PSP tray	Disposal. building mixed waste crushing and sorting NEDO	PET resin (for bottles) (PWMI)
Recycled distribution pallet	Disposal. volume reduction (PET bottle, bale) NRI	Tray formation (forming processing)
Combustion (discharge), other waste PS plastic	Disposal. volume reduction (PSP,bale) NRI	Pallet for mation (formingprocessing)
Combustion (discharge), other waste plastic	Disposal. volume reduction (aluminum can, press) NEDO	Palastic formation (inflation film) PWMI
Waste plastic, gasification (synthetic gas)	Disposal. volume reduction (aluminum can, press) NRI	Palastic formation (biaxial stretching film) PWMI
Waste plastic, conversion into cement fuels (chlorine bypass method) MJ	Disposal. volume reduction (steal can, press) NEDO	Polystyrene PS (PWMI)
Waste plastic, conversion into cement fuels (desalination) MJ	Disposal. volume reduction (steal can, press) NRI	PS film high-density polystyrene for lamination (PWMI)
Waste plastic, conversion into oil (hydrocarbon oil)	Disposal. volume reduction (other plastic, fluff / bale) PWMI	Packing material (HDPE bag)
Disposal. OA eguipment adovanced intermediate processing NEDO	Disposal. volume reduction (other plastic, bale) NRI	Packing material (LDPE)
Disposal. PCB destruction NEDO	Disposal. volume reduction (paper container, bale) NRI	Low-density polystyrene (PWMI)

5. Conclusion

The inventory data developed in this project contains data for only some of the required materials. Also, the inventory data related to disposal and recycling has been developed much slower than the inventory data for materials or products. Therefore, for the future, it is necessary to further improve the inventory data mainly for metal products especially precious metal materials, inorganic chemical products, and waste disposal. When using the data, it is necessary to understand how the data were developed and to use the data that matches the purpose of LCA being implemented.

5th International Conference: LCA in Foods	
Apr. 25-26, 2007 Gothenburg, Sweden	Swedish Institute for Food and Biotechnology http://www.sik.se/archive/dokument/LCAinfoods.pdf
7th Asia Pacific Roundtable for Sustainable Consumption and Production	
Apr. 25-27, 2007 Hanoi, Vietnam.	APRSCP http://www.7aprscp.com/
International Symposium on Electronics and the Environment	
May. 7-10, 2007 Orlando, USA	IEEE http://www.regconnect.com/content/isee/
SETAC Europe 17th Annual Meeting -Multiple stressors for the environment - present and future challenges and perspectives-	
May. 20-24, 2007 Porto, Portugal	SETAC http://www.setaceumeeting.org/porto/home/home.htm
14th CIRP International Coference on Life Cycle Engineering	
Jun. 11-13, 2007 Waseda University, Japan	International Academy for Production Engineering http://cirp-lce2007.jspe.or.jp/
ISIE Conference 2007	
Jun. 17-20. 2007 Toronto, Canada	ISIE http://www.is4ie.org/
Eco-Efficiency for Sustainability - 3rd International Workshop: "Foundations for trade-offs in practical decision making	
Jun. 21. 2007 Toronto, Canada	CML, Leiden University http://www.eco-efficiency-conf.org/
2007 ASME International Design Engineering Technical Conferences	
Sep. 4-7. 2007 Las Vegas, USA	ASME https://www.asmeconferences.org/IDETC07/index.cfm
International Life Cycle Assessment & Management 2007	
Oct. 1-5. 2007 Portland, USA	American Center for Life Cycle Assessment http://www.lcacenter.org/future-inlca.html
Sustainable Innovation 07	
Oct. 29-30. 2007 Surrey, UK	Centre for Sustainable Design http://www.cfsd.org.uk/
World Energy Congress -Rome2007-	
Nov. 11-15. 2007 Rome, Italy	World Energy Council http://www.rome2007.it/
SETAC North America 28th Annual Meeting-Urban Environmental Issues: Impacts on Ecological Systems-	
Nov. 11-15. 2007 Milwaukee, Wisconsin, USA	SETAC http://milwaukee.setac.org/
SETAC Europe LCA Case Study Symposium -LCA of Energy - Energy in LCA -	
Dec. 3-4. 2007 Göteborg, Sweden	SETAC http://www.setaceumeeting.org/LCA2007/

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