

LCA International: LCA in Japan

LCA in Japan: Policy and Progress*

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* Generated from a presentation at "Ökobilanzen VI", UTECH Berlin '98

Abstract

A summary of the current Japanese activities related to Life Cycle Assessment are presented with a specific comparison of Life Cycle Impact Assessment in relation to European tendencies. Japanese organizations involved in LCA, recent legislation impacting LCA activities and LCA case studies are also tabulated. The LCA priorities of policy makers and industrialists are discussed in comparison and compared to those in the United States. Projects within the Life Cycle Assessment Society of Japan and the Man-Earth Project are highlighted including the construction of a public LCI data base and the prediction of 21st century environmental crises.

Keywords: Ecobalance; ecometrics; Japan, LCA; Japan; LCA, policy and progress in Japan; LCA; Life Cycle Assessment (LCA); life cycle management; policy and progress, LCA in Japan

1 History of LCA in Japan

Life Cycle Assessment (LCA), as a term, was introduced in the Society of Environmental Toxicology and Chemistry following their Vermont workshop in August 1990. Prior to this, in the 1970s, various consulting companies and universities in the US and environmental centers in Europe respectively conducted "Technology Assessments" or "Substance Flow Analyses" which embedded much of what LCA would become. LCA was formally recognized in Japan with the creation of the industry sponsored Japan LCA Forum in 1991), although assessments were carried out as early as the mid 1980s. Between 1993 and 1998 the Ecomaterials Project has conducted systematic LCA studies. MITI subsequently sponsored the LCA Society of Japan (1995). International conferences in "Ecobalances", chaired by Professor YAMAMOTO, have occurred biannually since 1994. While the Japanese may not have been very active in the development of LCA per se, they have been at the forefront of the government-industry cooperation, specifically with the integration of life cycle concepts into decision making, reporting and public education, as will be detailed herein.

2 Legislation

The 1995 packaging law, which is similar to the German take back legislation, has forced a new level of compliance on Japanese companies. Since 1997, firms have been responsible for the collection of their products at their own expense. This legislation is delayed until 1999 or 2000 for certain products such as plastics. Japan also passed a recycling law which came into effect in October 1991. The aim of this legislation was to promote recycling with specific roles assigned to government, municipalities, industry and consumers. The 1993 amendments to this law include the promotion of waste minimization and the imposition of strict regulations on waste handling agents and treatment facilities. As of March 1995, rubber automobile tires, television sets with screens of 25" or larger, electric refrigerators with capacities of 250 L or more and spring mattresses were designated as "specially controlled wastes" [1]. As is the norm for most industrialized countries, construction and agriculture account for the majority of the solid waste generation. In Japan, in part due to the extensive use of incineration, the ratio of recycled resources to discarded material remains at approximately 1 to 10. Table 1 summarizes recent Japanese legislation which involves LCA.

3 Organizations with LCA-Related Activities

The results of recent conferences [2] have indicated that Japanese companies have three LCA-related types of interest:

- 1) in Type I applying LCA to Ecodesign
- 2) in Type II Ecolabeling as a certification criterion in a program such as the Blue Angel
- 3) in Type III Ecolabeling which basically involves as environmental report card similar to what is in place in the United States.

The Type III environmental labeling will require the performance of a Life Cycle Inventory and "Technical Committee

Table 1: Recent Japanese legislation with LCA implications

LEGISLATION (YEAR PASSED)	REQUIREMENTS
Recycling Law (1991)	<ul style="list-style-type: none"> Assigned specific roles to government, municipalities, industry and consumers in the effort to promote recycling 1993 amendments included the promotion of waste minimization and strict regulations on waste handling agents and treatment facilities As of March 1995, rubber auto tires, television sets with screens of 25" or larger, electric refrigerators with capacities of 250 L or more and spring mattresses were designated as "specifically controlled wastes"
Packaging Law (1995)	<ul style="list-style-type: none"> Similar to the German take back legislation Since 1997, firms have been responsible for the collection of their products at their own expense. The legislation is delayed until the years 1999 or 2000 for some products such as plastics

II" has been developed within the newly established Life Cycle Assessment Society of Japan (JLCA) to examine public database construction. The society also has specialized groups which examine LCA methods and which are active in the application of LCA (Technical Committees I and III, respectively).

JLCA was founded on October 25, 1995 and has two overriding objectives: the exchange of information and the establishment and use of common LCA data. They also work on facilitating the exchange of LCA information and the application of LCAs to environmental performance evaluations (EPE). Their initial program, through early 1997, also included training and consensus building. JLCA is funded by MITI and includes over 400 members from material, energy, construction and distribution companies, as well as from the educational and public sectors. The steering committee meets monthly. JLCA publishes a quarterly newsletter "Forum News" in Japanese. They also offer regular updates in the International Journal of Life Cycle Assessment [3].

Recently, JLCA issued a policy statement which included five specific proposals for promoting LCA [4]:

1. Industrial incorporation of LCA into business activities including planning, product and process design and internal prioritization.
2. Develop an efficient LCA method and construct a data base which is publicly recognized as a credible environmental assessment tool. This is being heralded as a means to move toward sustainable development.
3. Establish a national data base agency and a permanent LCA organization charged with upgrading.
4. Use the LCA method in combination with other tools or ecometrics for decision making.
5. Promote an enlightenment of the population in regard to LCA.

The LCA Center has been established in the Japan Environmental Management Association for Industry (JEMAI) to establish a public LCI database, as well as to develop life cycle impact assessment methodology. In April 1998, the Ministry of Agriculture, Forestry and Fisheries began an LCA project on sustainable agriculture, focusing on the rice and tomato sectors. Professor R. YAMAMOTO serves as the steering committee chair for the JEMAI LCI database and Sustainable Agriculture projects.

JEMAI will assume a role in education with respect to LCA and in the training of eco-auditors. JEMAI has an annual budget of 2 billion yen and has 1,400 member companies across such industrial sectors as those involving electrical power, steel, chemicals, automotive, electrical products, paper and cement. They initiated an ISO-committee on LCA in 1993. The specific Japanese plan for LCA includes a general survey, a discussion on how to use LCA and a third phase which evaluates alternatives for the development of extensive Japanese based inventory data bases and impact assessment methodologies. The latter, according to the JLCA chair, is the key issue. At present, the Japanese award the Eco Mark "to products that contribute to environmental protection" [5]. The basic requirements for Eco Mark certification are defined as reducing the environmental impacts and burdens at the various stages of the product life cycle. This program began in February 1989 and the product certification steps are conducted by the Japan Environmental Association under the direction of the Japanese EPA. The introduction of the Eco Mark occurred considerably later than Germany's Blue Angel program which began in 1978. However, it predates North American initiatives such as the Canadian Environmental Choice program which began in 1989 and the US Green Seal program which was started in 1993.

The Ecomaterials Forum, founded in 1993, conducted a study on the state of LCA research in Japan [6]. They concluded that the first LCA in Japan dates from studies in the mid 1980s on energy consumption carried out by the Chemical Research Institute. Other notable LCA studies in Japan

have included research on plastic products as carried out by the Plastic Waste Management Institute which was conducted in 1991. In 1992, the Japan Eco-life Center was entrusted with the responsibility to investigate the environmental burden of products by the Japan Environmental Agency. The following year, the Science and Technology Agency began the Ecomaterials Research Project in which the LCA of materials was taken into consideration.

In addition to the LCA Society, Japan has two other more established programs related to LCA. The six-year old **Japan LCA Forum**, chaired by Professor Itaru YASUI of the University of Tokyo Center for Collaborative Research was funded exclusively by approximately twenty companies to define LCA and its potential role in Japan. They have constructed an umbrella structure in order to extract information, aggregate it, and establish a data base. Another project which includes LCA components is the **Man and Earth System** which is funded by the Ministry of Education and is also directed by Professor YASUI. This contains 120 individual projects, some of which involve LCA. Its current projects on impact assessment and the prediction of environmental disasters in the coming century will be discussed in this paper.

The **Clean Japan Center** was established in 1975 and is sponsored by MITI. Its role is to introduce new technologies into the private sector and to local governments either from indigenous sources or, if necessary, abroad. They conduct seminars, construct test plants and lead the public relations efforts toward recycling. They also spent 3 billion yen in 1995 to assist companies in their environmental efforts. They are a member of JEMAI and their off-line database includes environmental information and legislation worldwide.

The **National Institute for Environmental Studies (NIES)**, a government laboratory, is an arm of the Japan Environment Agency. Led by Dr. ISHII, NIES¹ is divided into two divisions: (1) Social and Environmental Systems and (2) Natural Resource Management, and has a small program on LCA-related projects. Research on general LCA approaches includes data collected from over 500 industrial sectors. Studies include the interactions between industrial sectors, product stewardship practices, stipulations in the recycling law, design for X approaches and standardized environmental assessment methodology issues.

The **Resource Recycling Center (RRC)** is a group comprised of approximately 40 private companies. The RRC drafted the guidance regarding the environmental management systems component of the ISO 14000 legislation. Companies which have developed EMSs can be certified by the **Japan Accreditation Board for Quality Systems Registration (JAB)**. Table 2 presents a condensed list of key LCAs performed to date in Japan while Table 3 summarizes Japanese organizations and coordinated research projects with LCA-related subjects of interest.

¹ Dr. Sukehiro GOTOH, a former director of NIES, now leads the Waste Management Institute.

Table 2: Current Japanese LCA case studies

Case Studies	Industries
Air Conditioner	Agricultural Products
Alloys (Steels, Al, Mg)	Aluminum
Biodegradable Plastics	Automobile
Building (LC-CO ₂)	Building
Bullet Train (JR-Shinhansen)	Business Equipment
Ceramics	Cement
Recycling	Chemical
Rice and Tomato Production	Computer
Surface Treatment	Department Stores
Television	Electrical Equipment
Waste Treatment	Electric Power Generation
Wood Products	Gas
Workstation	Machinery
	Oil
	Pulp and Paper
	Shipbuilding
	Steel
	Wood

Table 3: Japanese organizations with LCA-related subjects of interest

Japan LCA Forum
LCA Society of Japan (MITI)
Japan Environmental Management Association for Industry
Man and Earth Systems Project (Ministry of Education)
Clean Japan Center (MITI)
Resource Recycling Center
Ecomaterials Forum
Japan Eco-life Center
Japan Accreditation Board for Quality System Registration (MITI)
Japanese EPA
National Institute of Resources and the Environment
NEDO Branch of MITI
Science and Technology Agency
Plastic Waste Management Institute

4 LCA Priorities: A Japan/US Comparison

In terms of environmental burdens, a recent Fortune 500 survey found US firms equally interested in air, water and solid waste streams [7]. When a similar question was posed to Japanese experts in environmental management, they clearly stated that solid waste was the most significant current problem and concern in Japan. This is particularly true for construction companies which generate 100 Mt/y in solid waste. This US-Japan difference is likely to be due to two effects.

First, Japan has a limited number of landfill sites and 80% of the solid waste is burned (3% for energy recovery).

Secondly, existing Japanese legislation has already forced companies to address their atmospheric and aqueous discharges.

In the same US survey, companies reported that pollution prevention, product stewardship and design for environment were the three motivations for performing an LCA. In an informal and non-systematic survey of Japanese companies, consultants and university professors, the main Japanese concern was Design for Environment.

Other comparative results from the US Fortune 500 survey and the informal Japanese interviews indicated that the use of interdisciplinary teams for conducting LCAs in both countries is still limited, with the involvement of top management at approximately one-third. The legal and accounting department of large firms are not yet included in the LCA process with the exception of a few percentage of the companies.

Both the US and Japanese governments do not plan to use LCA as a legislative tool. 57% of US companies reported that cost or market were the driving forces for their LCA efforts and they ranked quality above cost, performance and environmental concerns. The informal Japanese survey had cost and price consciousness above quality. The LCA practices of multinational firms located in Japan tended to follow the environmental lead taken by the head design center in the home country. Tables 4 and 5 summarize the results of the executive surveys carried out in the Japan and the United States, respectively.

5 LCA-Related Projects

The Man-Earth research project began in April 1993 and has a five year mandate. Its final target is the sustainability of the human race in Japan and East Asia, and it operates on a modest total budget of 300 million yen. Topics of debate within the project include the evaluation of sustainability by LCA, the extension of LCA to include social costs and the simplification of LCA and life cycle impact assessment. The latter includes crisis prediction for the 21st century, a time scale description of the crises, an evaluation of the temporal consumption due to human activity and a fatality evaluation of the crises. Table 6 summarizes forecasted environmental crises in the next century as predicted by expert panels assembled as part of the Man-Earth project. These crises vary from impacts related to production and end of life cycle issues such as solid waste disposal early in the century, to economic and material scarcity impacts between 2020 to 2040. The issues of population rise (currently 81 million per annum), habitation space, relocation and sea water level changes are also forecasted [8].

One focus of the Man-Earth project is the development of value systems or weighting factors for life cycle impact assessment. Figure 1 compares the Swedish EPS, Swiss EcoPoint, Dutch EcoIndicator methods with NAGATA's

Table 4: Japanese LCA survey results

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1. LCA-related interests focus on DFE and Ecolabeling
 2. Solid waste was identified as the most significant current environmental problem in Japan
 3. The Japanese EPA does not plan to use LCA as a legislative tool
 4. Japanese companies ranked cost above quality whereas US firms gave the opposite ranking
 5. Interdisciplinary teams are not extensively used to address LCA-related problems
 6. LCA practices of multinationals follow the lead taken in the home country
 7. Firms have reported good publicity from their environmental efforts
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Table 5: Summary of the 1995 LCA Survey of American Fortune 500 Executives

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1. Environmental valuations concentrate on the manufacturing, use and disposal stages of the product life cycle. Few companies consider raw material acquisition or transportation
 2. For 57% of the companies, the primary driver in their environmental efforts were either market or cost
 3. Companies reported relatively uniform concern for atmospheric, aqueous and solid waste based pollutants
 4. Over 50% of firms have either developed or partially implemented LCAs
 5. 42% of companies were adopting policies equal to or more stringent than the proposed ISO 14000 guidelines. However, 38% of respondents indicated that they were unaware of the environmental management component of ISO 14000
 6. LCA activities are not well integrated across corporate functions. In particular the accounting and legal departments, who can considerably contribute to life cycle costing, were excluded. Top management involvement was low (30%), but increased over previous surveys in 1992
 7. In terms of environmental priorities, Human Health was valued above Ecological Health, Resources, and Social Welfare. The later three are reported in descending order of importance
 8. Data-related problems such as incomplete data, data quality and outdated information were the main drawbacks reported for environmental assessments
 9. Most firms use both quantitative and qualitative metrics to evaluate environmental impacts. In the latter category, ranking and clustering are the most commonly reported methods
 10. Over 40% of the companies are engaged in life cycle costing
 11. Obstacles to LCA include the cost, difficulty to define boundaries and resistance to initiating LCA activities within a firm
 12. The major recommendations included focusing on impact assessment and incorporating costs into LCA
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Table 6: Prediction of Japanese environmental crises in the 21st century (Man-Earth Project)

Year	Predicted Environmental Crises
2005	<ul style="list-style-type: none"> Shortage of waste landfill sites Increase in CO₂ emissions
2010	<ul style="list-style-type: none"> Poor harvest due to low temperatures Sharp increase in UV radiation Increase in EDC concentration
2015	<ul style="list-style-type: none"> CO₂ emission control abandoned
2020	<ul style="list-style-type: none"> Price increase in crude oil Pollution due to low economic activity (closed chemical complex) Prepare to build lunar base
2030	<ul style="list-style-type: none"> Heavy metal contamination due to coal or geothermal power plants and advanced electronic devices Shortage of phosphorus Regulation for lead recovery Regulation for incineration (Japan)
2040	<ul style="list-style-type: none"> Sharp increase in population Shortage of crude oil Increase in nuclear power
2050	<ul style="list-style-type: none"> Space habitation for solar power satellites Sea water level clearly changes Population reaches 10 billion

weightings which are based on questionnaires given to Japanese environmental scientists, university workers, industrialists and housewives.

Clearly, NAGATA's method provides a more uniform valuation between solid waste, resource consumption, energy consumption, air pollution, acidification and global warm-

ing than the European methods. Furthermore, NAGATA's system avoids an overemphasis on a single impact: EPS prioritizes resource consumption, the EcoPoint favors air pollution and the EcoIndicator places an emphasis on heavy metal derived impacts. Itaru YASUI has defined a fifth value system which calculates the impact factor as the "Fatality" divided by a scaled consumption figure:

$$F_i = \frac{\text{Fatality}}{\text{Years}} \tag{1}$$

where "Years" is defined as the consumption by one unit of the product divided by the annual consumption within the boundary. Boundaries are global for impacts such as global warming, ozone depletion, and energy and resource consumption, while local systems are defined for atmospheric and water based pollutants, solid waste and eutrophication. Figure 2 plots the impact factors developed by YASUI for the Man-Earth project.

In relation to the European methods and NAGATA's procedure, a larger weighting is provided to solid waste and energy consumption, two Japanese priorities, as well as to carcinogens. Air pollution is slightly less valued, as was indicated in the Japanese LCA survey [10] since Japan has already made significant progress in this area. As would be expected based on the negotiations at the recent Kyoto conference, the Europeans have a stronger preference for global warming as a metric of sustainability. In contrast, the Man-Earth project has defined three broad categories of ecometrics:

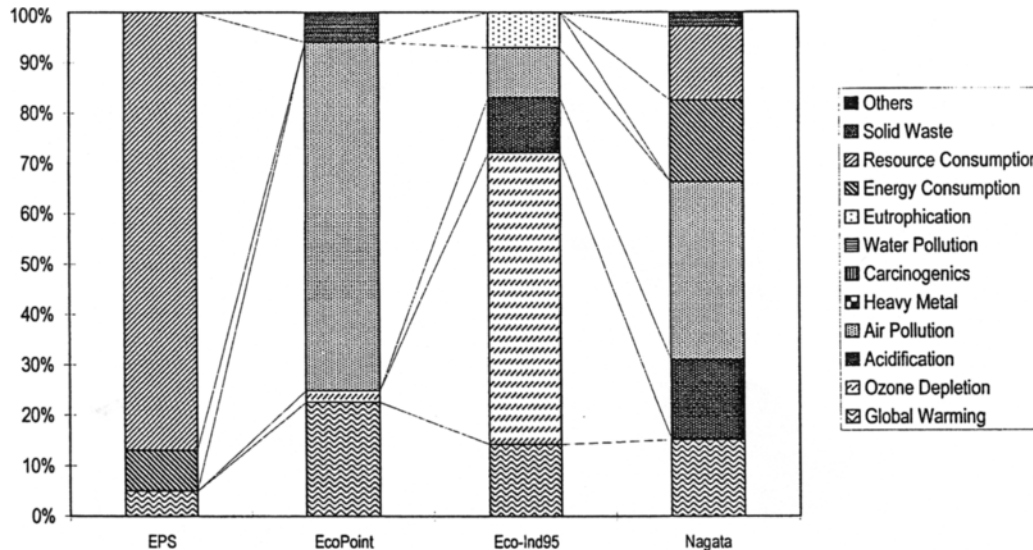


Fig. 1: A comparison of the Life Cycle Impact Assessment methodologies
 a) EPS: Sweden's method based on the willingness to pay
 b) Swiss EcoPoint based on the environmental capacity of the nation
 c) Dutch EcoIndicator'95 based on effects to the European ecosystem
 d) NAGATA's methodology representing a Japanese civil vies of the environment. Figure 1 is courtesy of A. TERAZONO [10]

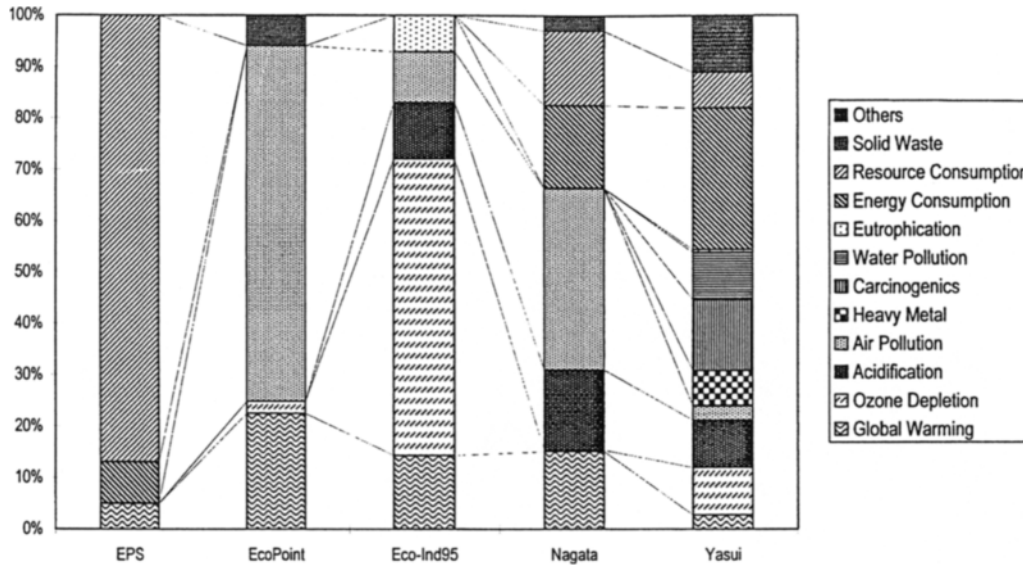


Fig. 2: A comparison of the four Life Cycle Impact Assessment methodologies in Figure 1 with YASUI's new balanced value system

1. Resource depletion
2. human health
3. ecosystem health.

The difference in the impact assessment methodologies stem from their definition and unique continental phenomena. For example, Sweden's EPS system is based on a willingness to pay, while the EcoPoint represents the environmental capacity of Switzerland. The Dutch EcoIndicator '95 is based on the European ecosystem. In contrast, the methods of NAGATA and YASUI define all consumption and emissions on a global scale, where the world is assumed to be equal to a region, i.e. a global-local equivalence. YAMAMOTO and coworkers, in collaboration with JEMAI, have also been developing a method similar to the Dutch EcoIndicator '95 method, which is based on Japanese environmental conditions (→ Table 7).

The University of Tokyo participates in the Alliance for Global Sustainability with the Swiss Federal Institutes of Technology and MIT. In addition to annual meetings which

rotate amongst the three countries, funded projects included global environmental change, the future of cities, energy generation and cleaner technologies. The alliance funds technological and policy based research projects and, in 1998, has emphasized collaborations with developing countries. The World Business Council for Sustainable Development has a program on Ecoefficiency to which several Japanese companies participate, illustrating via cases and data the link between environmental performance and shareholder value.

6 LCA and the Urban Infrastructure

The following case summary illustrates how local and national policy are being formulated, and implemented, in regard to the control of environmental burdens. In April 1996, the self-imposed control of small PET bottles in Tokyo was stopped, partly because of the success of imported mineral water bottles with volumes of less than 500 mL. The Tokyo metropolitan government asked to continue the control because it's absence could possibly increase the

Table 7: Ecoindicators of representative materials evaluated by various methods [11]

Method/ Material	ITSUBO ^a and YAMAMOTO	Eco-Indicator 95	EPS	EPS 1996	EcoPoint	MIPS
Steel	1.00	1.00	1.00	1.00	1.00	1.00
Aluminum	2.93	3.12	1.33	1.51	17.81	1.22
Secondary aluminum	0.20	0.15	0.14	0.22	0.53	28.05
Copper	4.48	5.52	2.39	2.28	35.71	14.30
Glass	0.19	0.12	0.15	0.23	0.19	0.29
PolyPropylene	4.76	3.90	2.42	3.41	6.57	-
Polyethylene	4.51	3.61	2.45	3.48	5.00	-

^a ITSUBO and YAMAMOTO have estimated these values using a distance to target method similar to EcoIndicator'95. However, it includes the environmental impact due to resource depletion and is based on Japanese environmental conditions

amount of solid waste to be landfilled (the official statement of the Tokyo metropolitan government is that PET is not suitable to be incinerated). A new regulation for containers which distributed the duty, and cost, of PET recycling came into effect in the following year (1997). Consumers bare the responsibility for separation in their own residence, whereas the local government assumes the cost of collection (21-29 yen per bottle). Local industry then reuses the PET for new products (cost 1.4 yen per bottle). This effectively answers the question of who should pay for recycling by placing the burden on the consumer rather than by applying a local tax. Presently, the Tokyo metropolitan government and distributors have reached an agreement to cooperate in the collection of empty PET bottles in selected stores. However, this will only be the first step towards new social regulations regarding the handling of plastic bottles in Japan.

7 Conclusions

This paper is concise by necessity. Therefore, since Japanese progress in LCA has been rapid since the foundation of the Japan LCA Forum in 1991, the paper has attempted to represent rather than summarize or catalog Japanese LCA-related activities. Large industry is now committed to the routine use of LCA as part of their decision process and the government recognizes that the life cycle management of products plays a key role in the implementation of their policies [12]. Numerous cases have been conducted, and diverse and interdisciplinary research is underway. Biannual international conferences on Ecobalances also forge international alliances and permit comparisons. Clearly, the three main global economic zones (North America, Europe, East Asia) face diverging challenges. The geography, resource intensity and population densities force policy makers, implicitly, and researchers, explicitly, to value various environmental stressors and impacts differently. In Japan, the commitment to funding LCA-related projects and entrenching LCA as a component of normal business practices has integrated environmental, economic and national policy considerations. Clearly, if one were to prepare this paper two years from now, its focus would be quite different.

However, the infrastructure is in place in Japan to effectively carry out and disseminate LCA information and to involve and educate all stakeholders. Projects are also underway to link national and international goals related to sustainable development to more local or commercial measures or metrics which can indicate the path or progress toward this objective.

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Errata

The *Int. J. LCA* 3 (2) 86-94 (1998), "Application of the Impact Pathway Analysis in the Context of LCA" pp. 92, Table 2. Please substitute "per kWh" by "per TWh".

The *Int. J. LCA* 3 (2) 75-79 (1998), "Automobile Air Conditioning: A Case Study of CFC Replacements" pp. 78, Table 2. Please substitute "ktonnes CO₂ equivalent" by "kg CO₂ equivalent".