Development Bank of Japan Research Report No. 45

How Life Cycle Assessment (LCA) Can Enhance the Fight against Global Warming

Overview

Life cycle assessment (LCA) is now entering the practical stage. This report describes the current state of LCA, focusing in particular on the Type III ecolabel. It also analyzes the structural obstacles impeding implementation of global warming measures that are in the interests of society as a whole. From an LCA standpoint, it recommends total optimization of global warming measures.

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Summary

1. Japan's greenhouse gas emissions are on the increase, diverging sharply from the emissions reductions target prescribed in the Kyoto Protocol. With emissions expected to go on rising in the transportation, domestic, and commercial sectors, additional measures are essential.

Japan's present strategy for fighting global warming is underpinned by the Guidelines for Measures to Prevent Global Warming. Listing over 200 measures, these Guidelines basically comprise a potpourri of measures designed as local optimums in the individual sectors of industrial, commercial/residential, and transportation. There is a mismatch between management capacity within each sector and the incentives for implementing the measures. For example, say a company in the manufacturing sector reduces emissions by developing and marketing more efficient equipment, or reduces emissions generated through distribution of its products. Those amounts are not factored into reductions under its voluntary action plan stipulated for industry sector emission reduction.

In the transportation sector, private automobiles contribute the largest percentage of CO_2 emissions. Not only do they account for over half overall emissions; their emissions have risen sharply since FY 1990. In the residential sector, electric power etc., where emissions have grown dramatically since FY 1990, accounts for the biggest piece of the pie. But the exact breakdown within that category has changed considerably. Refrigerators, though still one of the biggest sources of emissions, account for far fewer emissions than they used to. On the other hand, "washlet" toilet seats (toilet seats with built-in automatic bidet), which did not even exist before, have assumed a 5% share. In the commercial sector, too, electric power etc. has experienced a dramatic rise, in part due to the progress of office automation.

2. The usage stage accounts for the overwhelming percentage of CO_2 emissions from private automobiles, as shown by an examination of the emissions generated over the course of the whole life cycle; direct emissions by the assembler are a mere 3% of the total. It would be best if car assemblers optimized choice of materials while bolstering energy efficiency at the usage stage, but under current circumstances incentives do not work properly. While consumer behavior is important, there are also other problems in the form of lack of incentives and limitations of information and capacity. There are cases of, for example, photocopiers whose life cycle emissions have been more than halved by slashing emissions at the usage stage, when the CO_2 emissions load is heaviest. Greater effort has gone into reducing emissions at the production stage than at the usage stage, but achieving quantitatively significant reductions at that stage is difficult. The CO_2 emissions reduction strategies currently being pursued at the production stage are often relatively speaking fairly expensive. Many of Japan's industries boast the highest levels of production energy efficiency in the world; hence there is not that much room left for further reductions. On the other hand, there are certain products that reduce overall emissions by dramatically cutting emissions at the usage stage, but greatly increase emissions at the materials production and manufacturing stages. Such products are to the benefit of society as a whole, yet their manufacture is discouraged by a sector-by-sector approach. The stage at which the emissions load is heaviest varies considerably from item to item; the usage stage is not necessarily the most emissions-intensive. It is important to conduct a life cycle assessment (LCA) on each product and properly identify problem areas.

Limited number of companies as yet perform LCAs; a mere handful make the results public. Approximately half of companies with sales of over ¥500 billion perform LCAs, but few

companies with sales of under ¥500 billion do so. A survey of recent corporate action in the LCA field reveals that manufacturers of electrical equipment are taking a wide range of measures, including steps for environmental accounting purposes. Certain general equipment and chemical manufacturers have taken steps to disclose information on environmental load by for example obtaining Type III ecolabel certification.

3. LCA is a method of quantitatively assessing the ecological impact that a product has over the course of its whole life cycle: resource inputs, environmental load, and so forth. It originated in an attempt to gauge the environmental impact of beverage packaging circa 1970, and took a major step forward when work began in 1993 on establishing ISO standards on principles for LCA. Japan, which once lagged behind Europe and North America, has been rapidly catching up. For example, it made progress in constructing a database under Phase I of the LCA Project, a national project launched in 1998 involving industry, academia, and government.

Phase I of the LCA Project succeeded in constructing a database consisting of some 550 items of inventory data. With the cooperation of 54 industry associations, extensive and deep database was constructed like no other in the world; moreover, the task of collecting data in itself raised the level of LCA knowledge among companies.

One way to utilize LCA is the Type III ecolabel, which presents environmental information from an LCA in quantitative terms. The Type III ecolabel, for which an international standard is to be established in 2006, promises to come into widespread use. In Japan the EcoLeaf and EPD are currently in use. Many final products, such as office equipment and cameras, are EcoLeaf-certified, but the EcoLeaf is not in very extensive use in the materials and non-manufacturing sectors. EPD is typically used for intermediate products.

4. The current database is limited in terms of data accuracy and use because of problems in making adjustments for overlapping and missing data and such constraints on data collection as corporate secrecy. The relative difficult of compiling data varies due to differences in the value of LCA data depending on the product and technical obstacles such as variations in product design and method of manufacture. Only a small amount of the data can currently be put to practical use, even at the level of the individual firm, and even that is not of high quality; therefore the database will need to be further refined.

A host of challenges remains to be overcome in promoting LCA use: ensuring comparability of data, obtaining outside data, shortening the time LCAs take, a dearth of personnel qualified to use LCA, lack of understanding on the part of consumers, restrictions on Type III ecolabel use, ensuring compliance with legal regulations, etc. But, while such problems do exist, they can each be dealt with. An environment has emerged where the LCA can be put to gradual use. It is to be hoped that use of LCA will expand through provision of appropriate public support, such as assistance to medium and small businesses in the materials and components fields when conducting their first LCA.

5. Firms in the private sector are taking various ingenious approaches to overcoming these problems. There are examples of medium and small businesses obtaining Type III ecolabel certification, or of companies developing systems for efficiently collecting and processing LCA data. Gradual progress is also being made in what would appear to be more challenging areas, such as taking steps to utilize LCA in so-called design for environment (DfE). There are numerous reported cases of global warming measures in the industrial sector contributing to reductions in the transportation or commercial and residential sector. Further progress can be expected as long as planned, systematic support is provided.

LCA offers a wide range of advantages. For example, it allows companies to manage environmental load effectively and efficiently in all aspects of their operations. But there are caveats, such as the discrepancy between who bears the cost and who enjoys the benefits, or the time lag until LCA benefits are realized. As the example of hybrid vehicles demonstrates, estimated benefits vary greatly depending on such factors as conditions of use. It is to be hoped that the scope of the LCA will expand to cover all major environmental impacts from overall corporate operations on a global scale, rather than merely CO_2 emissions at home.

Implementing global warming measures that are effective from an LCA standpoint can only be accomplished to a limited extent by private-sector firms on their own, which after all do not enjoy all the benefits. Progress can be made in harnessing LCA as a means of achieving total optimization of global warming measures if the government, with its capability to make adjustments over time and between sectors, develops proper infrastructure and provides appropriate incentives.

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Introduction[1]

On March 19, 2002, Japan adopted the Guidelines for Measures to Prevent Global Warming (below termed simply the "Guidelines") in a session of the Global Warming Prevention Headquarters.[2] Then, in June 2002, it ratified the Kyoto Protocol following unanimous endorsement by both houses of the legislature. The Guidelines call for a review of progress in light of future emissions trends at certain key junctures (2004, 2007) as Japan strives to fulfil its Kyoto obligations. The first review falls in 2004.

The Guidelines comprise a potpourri of measures designed as local optimums in the individual sectors of industrial, commercial/residential, and transportation. Each measure is self-contained within the confines of a particular sector, whether industrial, commercial/residential, or transportation. For that reason there is a mismatch between management capacity within each sector and the incentives for implementing the measures. For example, companies in the manufacturing sector possess considerable management capacity. But that sector is basically required to implement rigorous steps to conserve energy only on the factory floor. Even if companies in the sector reduce emissions by developing and marketing more efficient equipment, or reduce emissions generated through distribution of their products, those amounts are not factored into reductions under voluntary action plans, which lay out the measures to be taken by factories in the manufacturing sector. So incentives to take such steps are lacking.

Life cycle assessment (LCA), a technique that first emerged around 1970, has evolved rapidly over the past decade. It is now entering the stage of practical use. LCA is a tool for quantitatively assessing and interpreting, for a specific purpose, the environmental impact of a product or service over the complete course of its life cycle from resource extraction through disposal and recycling. It shows promise for a wide range of applications. ISO14040, which defines the principles and framework for LCA, took force in 1997. International standards for Type III ecolabels, which objectively disclose LCA information as certified by a third party, are formally to come into effect in 2006.

An LCA-type analysis of CO_2 emissions from private automobiles, which produce huge amounts of greenhouse gases, reveals that 85% of those emissions are generated during the usage stage (the stage at which the consumer actually uses the car; in Japan this is generally assumed to be ten years and 100,000 km). By contrast, the assembly stage, when emissions reductions are imposed fairly rigorously, accounts for a mere 3%. It would be best if car assemblers optimized choice of materials while bolstering energy efficiency at the usage stage, but under current circumstances incentives do not work properly. Cutting emissions at the manufacturing stage often costs more relatively speaking, though they account for only a small percentage of the total; conversely, certain technologies that reduce lifecycle emissions overall actually increase emissions at the manufacturing stage considerably. The manufacturing sector has the capacity and management resources to cut overall life cycle emissions from products and services, but as things now stand that potential is not being properly tapped.

From this perspective, the present paper examines how LCA might be harnessed as a way of effectively achieving total optimization of global warming measures. It then considers what challenges stand in the way, and what role government should play.

Chapter I, "The Fight against Global Warming and Life Cycle Assessment (LCA)," describes the state of the fight against global warming (sectoral emissions and so forth), and summarizes the reasons why an LCA-type approach is needed. Chapter II, "The State of LCA Today and Cases of LCA in Use," examines the history of LCA, looks at instances of it in use -- as in the Type III ecolabel -- and surveys what progress is being made on the national project of developing LCA infrastructure. Chapter III, "Challenges to Overcome in Promoting LCA Use," provides a systematic overview of the ob-

[1] Takao Aiba wrote Chapters I, II, and IV of this report, as well as overseeing the whole. Hiromichi Kunimi wrote Chapter II.

[2] Headed by the Prime Minister, with the Chief Cabinet Secretary, the Minister of Economy, Trade and Industry, and the Minister of the Environment as his deputies. All other Ministers of State are members.

stacles that stand in the way of LCA use based on a wide range of specific examples collected through extensive interviews etc. Also discussed is the need for public support in overcoming these challenges. Chapter IV, "Utilizing LCA to Achieve Total Optimization of Global Warming Measures," surveys recent efforts by the private sector to overcome these challenges. It also identifies caveats to LCA use and presents a scheme for promoting global warming measures utilizing LCA.

In preparing this report we have benefited from the assistance and advice of many individuals representing a wide range of companies and organizations. We would like to take this occasion to express our gratitude to them all.

I Measures to Combat Global Warming and Life Cycle Assessment (LCA)

1-1. What Is Global Warming?

COP3[3], which convened in Kyoto in December 1997, adopted the Kyoto Protocol as the first step[4] in a sustained, long-term strategy to cut emissions of greenhouse gases. The Kyoto Protocol committed the developed countries to legally binding numerical targets for reducing emissions. Japan ratified the Kyoto Protocol in June 2002, thereby assuming an international obligation to reduce greenhouse gas emissions for 2008-2012 by at least 6% as compared to the base year (basically 1990) (Fig. 1-1).

Yet Japan's greenhouse gas emissions, like those of most of the developed world, continue to rise. Despite an array of measures and the slump in the economy, emissions for FY 2002 stood 7.6%[5] above those for the base year, which means that the country is already 13.6% in excess of its Kyoto target. By sector, emissions of carbon dioxide (CO_2), which account for 94% of overall greenhouse gas emissions, were, as compared to the base year, down 1.7% in the industrial sector, up 20.4% in the transportation sector, up 36.7% in the commercial sector, and up 28.8% in the residential sector.

Emissions of greenhouse gases can be expected to rise further in the run-up to the Kyoto commitment period of 2008-2012. Future levels of CO_2 and other emissions are extremely difficult to predict with certitude, since so many different factors come into play: not just forecasts relating to economic trends, industrial structure, and energy prices, but also for example progress in installing various types of new equipment. Fig. 1-1 gives a rough forecast of how emissions are expected to rise, with the transportation, residential, and commercial sectors accounting for the lion's share of the increase.

Japan's strategy for fighting global warming is underpinned by the Guidelines for Measures to Prevent Global Warming (below termed simply the "Guidelines") adopted on March 19, 2002 by Global Warming Prevention Headquarters. The Guidelines particularly emphasize measures to curtail emissions of CO_2, which account for such a large proportion of the total. It lists over 200 measures particularly in three separate sectors: industrial, commercial/residential, and transportation. These consist mainly of energy-saving measures on the demand side. In quantitative terms, voluntary action plans and in-plant measures in accordance with the Energy Conservation Law[6] predominate. In the commercial/residential and transportation sectors, the main focus is on improvements in equipment efficiency through the pursuit of Top Runner standards or the like, with few measures to curtail energy demand. On the other hand, a fair amount of importance is also attached to measures on the energy supply side, such as increased use of nuclear power and new energy sources mainly related to renewable energy.

Just as it is difficult to forecast future greenhouse gas emissions, it is also difficult to forecast the effectiveness of measures to combat global warming. The Guidelines therefore call for measures to be evaluated and revised in 2004 and again in 2007. Thus 2004 is the year of the first evaluation and revision process. The Guidelines prescribe reductions targets for FY 2010 in each of the three sectors -- industrial, commercial/residential, and transportation. When those targets are compared to the latest figures for actual emissions, the two appear to diverge

[3] The third session of Conference of Parties to the United Nations Framework Convention of Climate Change.

[4] Even if the world's countries -- including the United States -- were to abide by the Kyoto targets for reducing emissions, the net benefit, it is said, would be to curtail the rise in average temperature by a mere 0.2˚C or so; thus further dramatic reductions will be required in the future. Count the world's total greenhouse gas emissions flow as 100. The US, which accounts for roughly one quarter of that amount, has withdrawn from the accord; the developing countries, which account for another 40%, do not have a target for cutting emissions at all. That being the case, the reductions targets prescribed by the Kyoto Protocol cover a modest 30% or so of the world's total emissions flow, with in effect a mere 10% being subject to significant cuts. It will be necessary to take truly effective steps to combat global warming by preventing carbon leakage to countries not required to reduce emissions. See Aiba (2003).

[5] Emissions fell between FY 2000 and 2001 but then shot up again in 2002. There thus appears to be no change in the overall upward trend.

[6] Law Concerning the Rational Use of Energy.

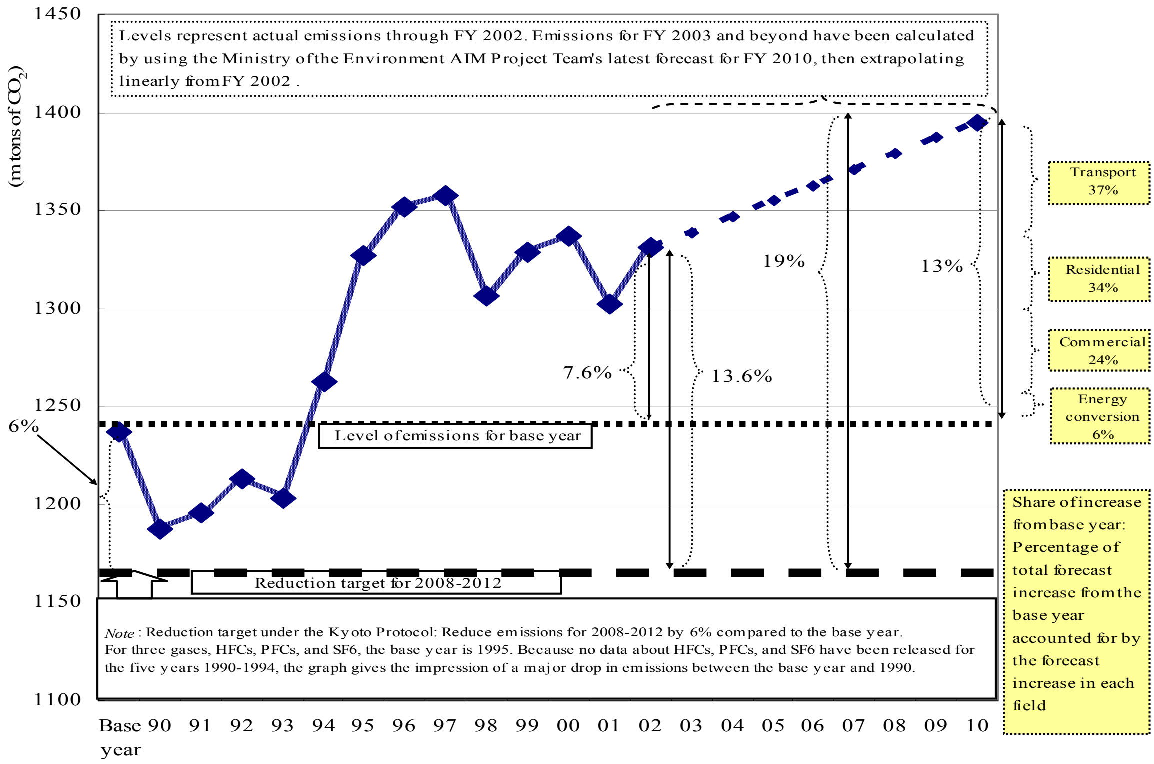

Figure 1-1. Japan's Greenhouse Gas Emissions: Actual and Predicted Levels

Notes:

1. As of FY 2002, Japan's actual greenhouse gas (GHG) emissions stood at 7.6% above those for the base year, this despite the slump in the economy. Emissions rose 2.2% over FY 2001 as nuclear power plants suspended operations, production increased, and number of households and commercial floor space both expanded. According to an estimate made by the Ministry of the Environment in summer 2002, emissions will increase some 13% by FY 2010. The increase could be even greater depending on how quickly construction of nuclear power plants proceeds and the state of the economy.
2. By individual sector, actual emissions as of FY 2002 were, compared to the base year:
   Down 1.7% in the industrial sector, Up 20.4% in the transportation sector, Up 36.7% in the commercial sector,
   Up 28.8% in the residential sector
3. Japan can claim a maximum deduction of 3.9% for absorption by forests and other sinks if 1.2 trillion yen is invested over the next decade.
4. There are six greenhouse gases covered by the Kyoto Protocol: CO2,methane, N2O, and HFCs and two other gases.

Sources: Compiled by DBJ from government data, Central Environment Council documentation, etc.

Table 1-1. Overview of the Guidelines for Measures to Prevent Global Warming

(m tons of CO_2)

	Industrial sector	Commercial/residential sector	Transportation sector
Energy saving measures	• Voluntary action plans and in-plant measures in accordance the Energy Conservation Law (approx. 61) • Install high-performance industrial furnaces (approx. 3)	• Enhance improvements in equipment efficiency through pursuit of Top Runner standards etc. (approx. 37) • Improve energy-saving performance of homes and buildings (approx. 36) • Promote commercial and residential energy management (approx. 11)	• Improve efficiency of vehicles etc. (approx. 21: 17 for vehicles in general, 2 for clean-energy vehicles, 1 for anti-idling vehicles, 2 on improving efficiency of airlines and trains) • Management of transport demand (approx. 10: 4 on promoting ITS, 3 on transport alternatives like teleworking, 2 on regulation of vehicle traffic demand etc., 1 on restricting road speed of large trucks) • Switch modes of transport (approx. 10: 5 on promoting use of public transport, 4 on modal shifts) • Streamline distribution (approx. 5)
New energy	Adopt new energy technologies (approx. 34: 4.82 million kW of solar power [1 million units for home use], 4.17 million kW generated from waste, 3 million kW of wind power, 4.94 million kl from black liquor and scrap wood, 4.39 million kl from solar heat [9 million units for home use], etc.)		
Nuclear power etc.	Increase nuclear generated power approx. 30% by FY 2010 compared to FY 2000 (approx. 50). Switch fuels for generating electric power from coal to natural gas etc. (approx. 18).		
Emissions levels	Target, FY 2010 462 Actual emissions, FY 2002 468 Divergence 6	Target, FY 2010 260 Actual emissions, FY 2002 363 Divergence 103	Target, FY 2010 250 Actual emissions, FY 2002 261 Divergence 11

Note: This chart includes only measures to curtail energy-derived CO_2 emissions, which represent approx. 90% of Japan's total emissions.

Sources: Compiled by DBJ from Global Warming Prevention Headquarters, *Guidelines for Measures to Prevent Global Warming* and *Greenhouse Gas Emissions in FY 2001*.

particularly dramatically in the commercial/residential sector.[7] If additional measures are to be considered within the framework of the current Guidelines, they will be required particularly in the commercial/residential and transportation sectors, which have a long way to go to meet their targets.

As a look at the details of specific measures reveals, the Guidelines basically comprise a patchwork of measures designed as local optimums in the individual sectors of industrial, commercial/residential, and transportation. These measures are all self-contained within their respective sectors; there are virtually no cross-sectoral measures except with respect to energy supply. There is a mismatch between management capacity within each sector and the incentives for implementing the measures. For example, say a company in the manufacturing sector contributes to reducing emissions by developing and marketing more energy-efficient equipment, or reduces emissions generated through distribution of its products or during commuting by its employees. Those amounts are not allowed for the company to factor into reductions under its voluntary action plan. This mismatch between management capacity and incentives will be examined further in Section 1-2.

1-2. The Transportation and Commercial/Residential Sectors: Emissions Up Dramatically

We analyze CO_2 emissions trends in the transportation sector using easily available data on energy consumption levels, since CO_2 emissions and energy consumption are virtually synonymous. As the pie graph shows (Fig. 1-3), in FY 2000 passenger transport accounted for 64% of total energy consumption; private automobiles in particular dominated overwhelmingly, accounting for 55% of the total. Energy consumption by private automobiles rose 40% compared with FY 1990; thus private automobiles account for the lion's share of the increase in the transportation

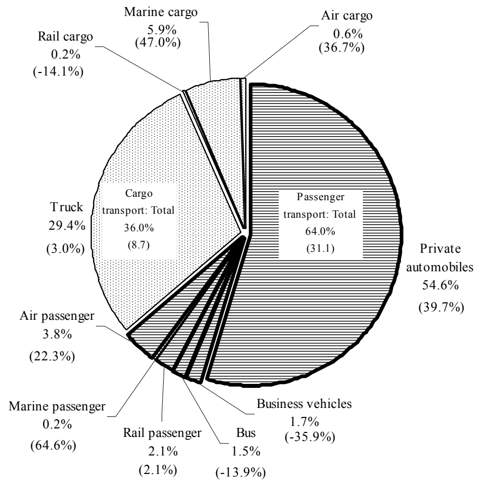

Figure 1-2. Energy Consumption in the Transportation Sector by Mode of Transport, FY 2000

Notes: Figures in brackets give the percentage increase 1990-2000.
Source: Compiled by DBJ from data contained in Energy Data and Modeling Center, Institute of Energy Economics, Japan, *EDMC Handbook of Energy & Economic Statistics in Japan* (2002 edition).

sector as well.

CO_2 emissions trends in the residential sector can, as in the transportation sector, be examined based on energy consumption. Electric power etc. accounts for the biggest piece of the pie, as well as displaying the highest rate of increase from FY 1990. Heating, with a 28% share of the total, also shows a high rate of increase, at 28%[8] (Fig. 1-3).

Let us examine the breakdown of the electric power component of the pie in greater detail. Refrigerators, at 19%, constitute the biggest single power-consuming appliance, although their relative share has declined dramatically since FY 1990, when it stood at 27% of the total. On the other hand, "washlet" toilet seats (toilet seats with built-in heated warter shower bidet), which hardly even existed in 1990, have assumed a 5% share; likewise, dishwashers have climbed from virtually zero to over 1%. Thus things have changed considerably. There has also been an increase in the share of "Other," probably attributable to the spread of information and computer

[7] The Japanese government changed the classification of emissions data from FY 2001; that makes it difficult to draw strict comparisons between the sectoral targets prescribed in the Guidelines and currently available data on sectoral emissions.

[8] This seems to a large extent due to an increase in the number of air conditioners.

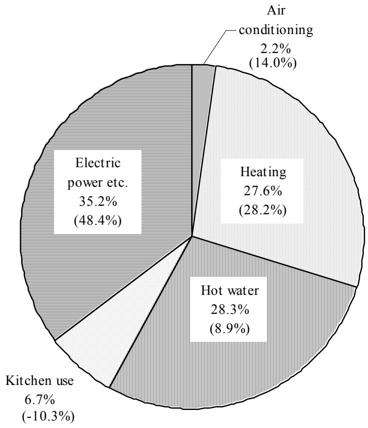

Figure 1-3. Energy Consumption in the Residential Sector by Type of Use, FY 2000

Note: Figures in brackets give the percentage increase 1990-2000.
Sources: Compiled by DBJ from data contained in Energy Data and Modeling Center, Institute of Energy Economics, Japan, *EDMC Handbook of Energy & Economic Statistics in Japan* (2002 edition).

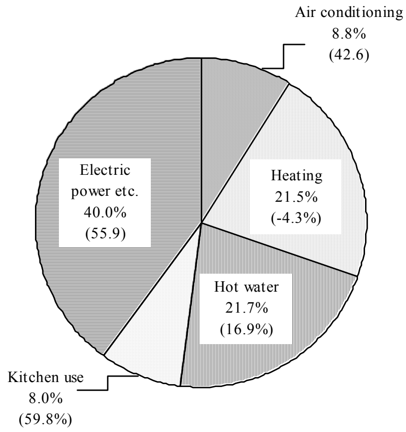

Figure 1-5. Energy Consumption in the Commercial Sector by Type of Use, FY 2000

Note: Figures in brackets give the percentage increase 1990-2000.
Sources: Compiled by DBJ from Energy Data and Modeling Center, Institute of Energy Economics, Japan, *EDMC Handbook of Energy & Economic Statistics in Japan* (2002 edition).

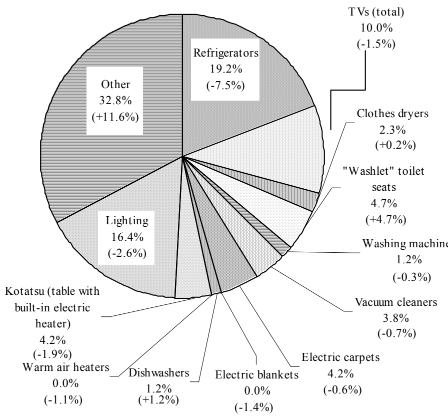

Figure 1-4. Energy Consumption for Power and Lighting per Household, by Type of Appliance, FY 2000

Note: Figures in brackets give share in 1990 minus share in 2000. The minus sign indicates a reduction in share.
Sources: Compiled by DBJ from data contained in Commercial/Residential Section, Energy Data and Modeling Center, Institute of Energy Economics, Japan, *Survey of State of Energy Consumption*.

technologies (Fig. 1-4).

In the commercial sector, electric power etc. not only accounts for the largest share; it has also displayed the most dramatic rate of increase, having risen 56% since FY 1990. This can be attributed to such factors as the progress of office automation.

As this analysis of energy consumption trends in the transportation and commercial/residential sectors demonstrates, it is especially important that energy-saving measures be taken with respect to automobiles, office equipment, and the like.

1-3. Importance of the Life Cycle Approach and Structural Challenges

Let us analyze the structure of private automobile emissions, which account for a large percentage of the increase in CO_2 emissions since 1990 and can be expected to continue to rise.[9] As

[9] Among the primary reasons for the increase in CO_2 emissions from private automobiles (accounting for 86% of the increase between FY 1990 and 2001) is growing car ownership due to a combination of increased rate of ownership per household and an increase in number of households.

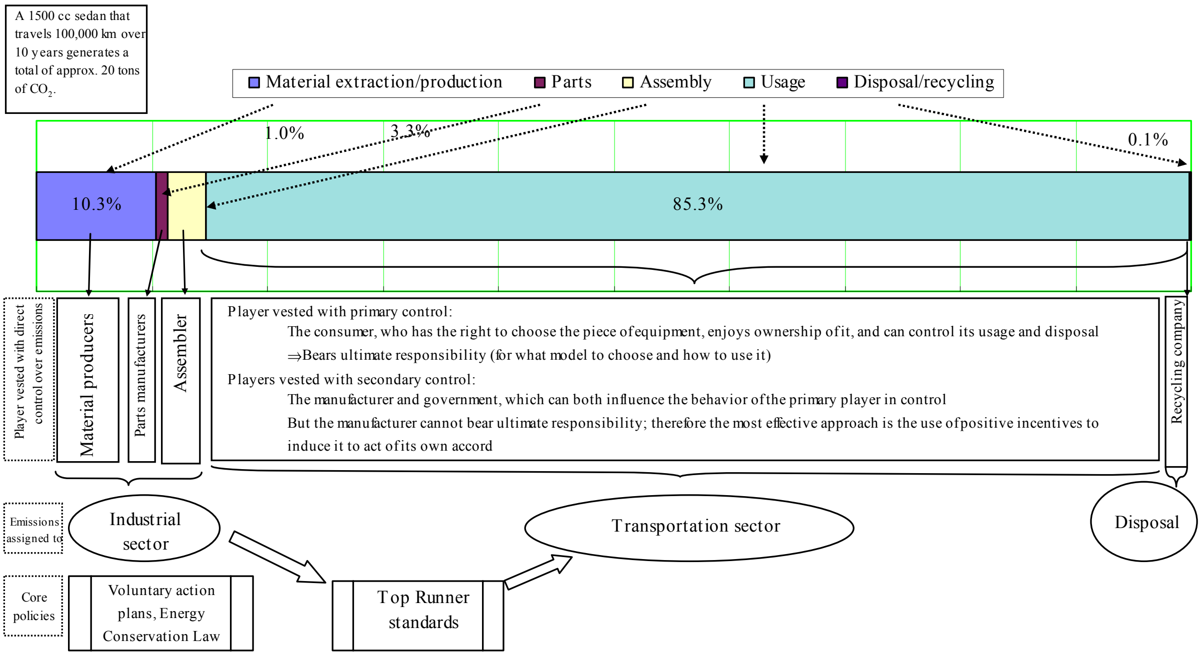

Figure 1-6. Breakdown of CO_2 Emissions over the Course of a Vehicle's Life Cycle, and Player Directly in Control of Emissions at Each Stage

Sources: Compiled by DBJ from, inter alia, data contained in Environmental Industries Office, Ministry of Economy, Trade and Industry, *Current State of the LCA Project and Approaches for the Future*, handout distributed at the LCA Five Year Project Briefing, Jun. 20, 2003.

evident from an examination of the emissions that an automobile generates over the course of its whole life cycle, from extraction and production of materials to disposal and recycling, the usage stage accounts for the overwhelming percentage of emissions (Fig. 1-6). Direct emissions by the assembler, which actually determines the automobile's design and performance, are a mere 3% of the total; parts production accounts for just 1%; even extraction and production of materials generate no more than 10%.

Refrigerators, which account for a high percentage of energy consumption in the home, likewise generate most of their emissions during the usage stage. In the case of a refrigerator, 92% of emissions occur during usage; assembly accounts for a mere 0.6% (Fig. 1-7).

Here, taking the automobile as an example, we consider the relationship between the party exercising direct control over emissions at each stage, the sector to which those emissions are assigned, and the core policies being pursued. The industrial sector faces strong pressure to cut emissions, these being fairly rigorously controlled under the provisions of the Energy Conservation Law and through voluntary action plans; hence material producers, parts manufacturers, and the assembler together account for a modest 15% of overall emissions.

The players vested with control over emissions during the usage stage, which accounts for 85% of all emissions, can be divided into primary and secondary players. The player vested with primary control is the party that has the right to choose the piece of equipment, enjoys ownership of it, and can control its usage and disposal -- in other words, the consumer. Players vested with secondary control are those parties

This is according to the analysis by the Energy Efficiency and Conservation Subcommittee, Advisory Committee for Natural Resources and Energy, Ministry of Economy, Trade and Industry (Handout 1, Energy Efficiency and Conservation Subcommittee Session 3, Feb. 24, 2004). However, since restricting car ownership would be problematic, here we focus on emissions structure per vehicle.

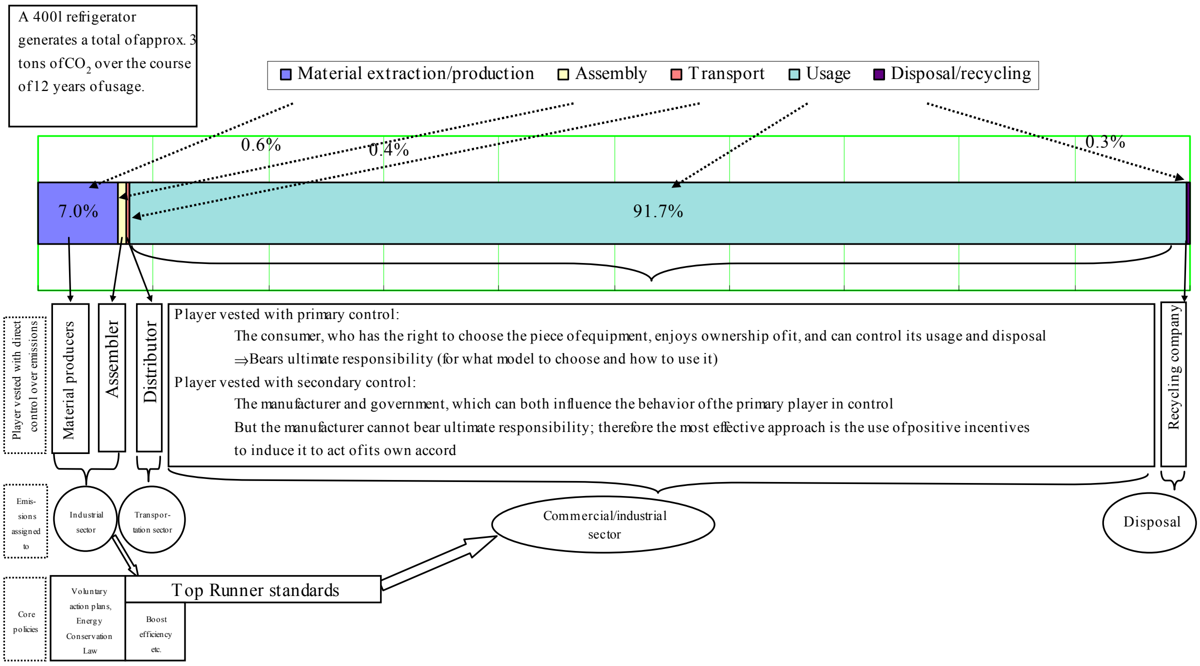

Figure 1-7. Breakdown of CO_2 Emissions over the Course of a Refrigerator's Life

Sources: Compiled by DBJ from, inter alia, data contained in Environmental Industries Office, Ministry of Economy, Trade and Industry, *Current State of the LCA Project and Approaches for the Future*, handout distributed at the LCA Five Year Project Briefing, Jun. 20, 2003.

able to influence, in some form or another, the behavior of the primary player. In this case that means the automobile manufacturer and the government.

The Energy Conservation Law requires any party in the business of manufacturing or importing energy-consuming machinery and equipment to make an effort to boost, by a specific target year, the energy consumption efficiency of the machinery and equipment it makes and sells, this in line with Top Runner standards.

As Table 1-2 illustrates, the Top Runner provisions of the Energy Conservation Law are characterized by their broad scope,[10] as well as by the flexibility with which they are applied: for example, the weighted average method has been adopted to ascertain attainment of targets.[11] And the program does appear to be yielding definite results. In its evaluation of the measures and policies contained in the Guidelines for Measures to Prevent Global Warming, a process which it commenced in 2004, the Central Environment Council has forecast that the targeted energy efficiency of equipment will indeed be satisfactorily attained by the respective target years. The Top Runner program has won high praise in Germany and elsewhere in Europe, and a move is reportedly afoot to adopt a similar set of regulations there. A mechanism is also in place to ensure that targets are met. If a manufacturer fails to attain a target, the Minister of Economy, Trade and Industry can in principle advise the manufacturer to take steps to boost performance; if it fails to abide by the advisory, the Minister can then make that fact public and order the manufacturer to comply. If the manufacturer fails to obey that order as well, a maximum fine of one million yen may be imposed.[12]

[10] Currently 18 items are designated under the program, including passenger cars, trucks, space heaters, and unit air conditioners. Around 80% of energy intensive devices are covered in some form or another. Even where specific items are subject to the program, in certain cases 30-40% of devices in that category may remain outside its scope; thus its effective coverage would appear to be less than 80%.
[11] This creates flexibility by, e.g., enabling manufacturers to bring out cheap models to cater to market needs as long as they also ship large volumes of equipment with a level of energy efficiency that matches or exceeds the target level.
[12] Law Concerning the Rational Use of Energy, Article 19, Article 28.2.

Table 1-2. Annual Energy Consumption Etc. of Energy-Using Equipment (1999 Estimates)

	Device	Ownership ('000s)	Units shipped, 1997 ('000s)	Energy consumption ('000s kl, crude equivalent)	Energy-saving target for designated Top Runner devices				
						Year set	Target year	Energy savings	Benchmark year
1	Passenger cars	40,998	7,128	44,094	Gasoline	1999	2010	23%	1995
					Diesel	1999	2005	15%	1995
					LP gas	2003	2010	11.4%	2001
2	Trucks (Top Runner program covers trucks with gross vehicle weight of under 2.5 tons)	8,553	1,739	34,350	Gasoline	1999	2010	13%	1995
					Diesel	1999	2005	7%	1995
3	Space heaters	45,877	6,281	9,439	Gas	2002	2006	1.4%	2000
					Oil	2002	2006	3.8%	2000
4	Unit air conditioners	80,874	7,888	8,392	Air conditioning/ heating	1999	2007 (partial achievement in 2004)	63%	1997
					Air conditioning only	1999	2007	14%	1997
5	Fluorescent lighting fixtures	422,466	50,959	7,956		1999	2005	16.6%	1997
6	Gas water heaters	28,937	3,386	7,539		2002	2006	4.1%	2000
7	Electric refrigerators and freezers (for household use)	54,825	5,540	2,945	Electric refrigerators	1999	2004	30%	1998
					Electric freezers	1999	2004	30%	1998
8	Oil water heaters	4,628	597	2,784		2002	2006	3.5%	2000
9	Cooking appliances (gas cooking appliances)	32,358	4,986	2,449		2002	2006	13.9%	2000
10	Televisions	102,189	9,792	1,589		1999	2003	16.4%	1997
11	Incandescent lighting fixtures	210,639	23,025	1,474					
12	Electric cooking appliances for kitchen	67,230	11,748	995					
13	Warm air space heaters	2,630	291	954	Gas	2002	2006	1.4%	2000
					Oil	2002	2006	3.8%	2000
14	Electric heating appliances (electric toilet seats)	35,883	5,792	757		2002	2006	10%	2000
15	Central processor units and personal computers	24,258	7,118	706		1999	2005	83%	1997
16	Vending machines (beverage vending machines)	2,597	431	705		2002	2005	33.9%	2000
17	Ventilation fans	144,094	9,649	509					
18	Showcases	2,137	334	358					
19	Motorcycles	14,537	1,188	312					
20	Videotape recorders	50,402	6,831	307		1999	2003	58.7%	1997
21	Input/output devices (printers and displays)	24,463	10,307	237					
22	Secondary storage devices (magnetic disk units)	28,585	8,287	215		1999	2005	78%	1997
23	Refrigerators/freezers, refrigerators and freezers (commercial)	1,074	211	203					
24	Stereo sets (incl. CD radio cassette recorders)	36,990	4,966	166					
25	Imaging devices (incl. facsimiles and multifunctional facsimile systems)	13,620	2,998	136					
26	Photocopiers (incl. multifunctional photocopiers; Top Runner program does not cover color, large-format, and high-speed copiers, nor multifunctional copiers with fax function)	3,997	1,350	127		1999	2006	30%	1997
27	Telephones (telephones with answering machine function)	27,594	3,583	124					
28	Fully automatic washing machines and twin-tub washing machines	31,093	4,858	93					
29	Vacuum cleaners	39,063	6,529	80					
30	Video deck players (incl. DVD players)	8,417	260	66					
31	Clothes dryers	2,794	405	60					
32	Word processors	8,410	1,210	4					
33	Electronic instruments (electronic keyboards and keyboard synthesizers)	1,965	445	0.07					
	Transformers (oil immersed)					2002	2006	30.3%	1999
	Transformers (cast resin)					2002	2007	30.3%	1999

Note: Hatching indicates devices already designated under the program.

Sources: Compiled by DBJ based on Handout 3 from Session 1 of the Energy Efficiency and Conservation Subcommittee (Advisory Committee for Energy), Dec. 25, 2003. This handout was compiled based on discussions during Session 4 of the Energy Saving Standards Subcommittee (Advisory Committee for Energy) in June 1999.

However, there are concerns as well. Target levels and deadlines end up being frozen, and items tend to be designated under the program all too slowly.[13] Take photocopiers, for example. Conventional analog machines are subject to Top Runner standards, but as measured in energy consumption around 35% of all photocopiers are not covered, including the increasingly popular multifunctional photocopiers, color copiers, large format copiers, digital copiers, etc.[14] Then there are cases such as that where the liquid crystal television is replacing the cathode ray tube: since the two are not directly comparable, Top Runner standards have difficulty in applying to the technology shift. So the Top Runner standards are well adapted to mature products, but problems may crop out when they are applied to items whose technology is currently in transition or evolves rapidly. In setting the target year for attaining a particular target, consideration is given to such factors as product development lead times and the prospects for future advances in technology. But predicting the future with total accuracy is no easy task. Therefore, the more sober-minded the industry, the more likely it is to set itself a conservative target that it can be sure of attaining. Global warming is triggered by the cumulative buildup of CO_2 emissions, and that makes prompt gains in efficiency (i.e., attainment of targets) desirable. But the Top Runner program is not very good at providing incentives to that end. It is best suited to situations in which the list of subject devices is largely fixed and there are reasonable prospects for improvements in the technology.

Thus regulation has its difficulties. Still, the government, with its power to enforce, and the manufacturer, with its prerogative to determine product design and performance, can exert an indirect impact on emissions during the usage stage through improvements in product efficiency and the like. Even so, only the player vested with primary control -- the consumer -- has the right to choose the product and decide how to use it; hence the government and manufacturer cannot really bear ultimate responsibility. For instance, it would be difficult to completely prevent, through regulation alone, a small-scale importer from selling a cheap but inefficient appliance. If one item requires even a slightly larger initial investment than another, though that investment may be recoverable in a few years, consumers may still go for the cheaper option. It is even more difficult to regulate consumer use. For example, in FY 1998 air conditioner power consumption per household had increased 63% compared to 1990. Yet a look at the figures shows that improvements in equipment efficiency resulted in 12% energy savings. Nonetheless, an increase in the number of air conditioners owned, in combination with such usage factors as hours and conditions of use, led conversely to a 75% increase in power consumption.[15] In cases like this it is necessary for the primary player in control, the consumer, who has the best grasp of energy needs, to show a commitment to reducing CO_2 emissions. That means forming an accurate understanding of the state of CO_2 emissions associated with energy use and selecting and using appliances in sensible fashion. It may be possible for outside parties to provide advice to consumers and furnish them with appropriate product choices. But unless the primary player in control acts with a commitment to reducing CO_2 emissions, measures are not likely to prove effective. Conversely, the lion's share of energy use by consumers is for essential purposes; that makes it difficult to provide effective incentives for reducing CO_2 emissions, short of imposing a fairly heavy carbon tax.[16]

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13 The Top Runner program does not apply to devices that are used for special applications, devices for which it is difficult to set targets per se because technology has not been developed for gauging and evaluating their performance, and devices that are in only extremely restricted use on the market. Thus items fail to come under the program until they have achieved a certain degree of market penetration. Where change is relatively frequent, such as in the case of household devices, the program may find it hard to keep up.

14 Global Environment Council of the Central Environment Council, Session 14 (Mar. 10, 2004), Handout 1-4.

15 Reference Sheet 2, Session 1 of the Energy Efficiency and Conservation Subcommittee (Advisory Committee for Natural Resources and Energy, Ministry of Economy, Trade and Industry), Dec. 25, 2003.

16 The short- and long-term price effects of a carbon tax need to be separately considered. A low carbon tax, it has been estimated, should possess a more pronounced long-term than short-term price effect, but the issue is not conducive to analysis on the assumption of an absolute

Table 1-3 provides a rough overview of the relationship between emissions sector and the players in control. The horizontal axis lists emissions sectors; the vertical axis lists the different players in control. The energy conversion sector is omitted here in order to simplify discussion, since energy differs considerably in nature from ordinary goods and services: for example, under business law providers are actually required to supply customers. The level of control capacity possessed by each player is indicated next to that player. As a general rule households do not have that much capacity to accurately monitor state of energy use and take appropriate energy-saving measures, but control capacity in other sectors is fairly high, albeit with differences of degree.

Consider the emissions sectors listed on the vertical axis. In the industrial sector, the emissions control structure is simple indeed. The emissions sector and player in control coincide, incentives are strong, and control capacity is high. This is consistent with the definite progress being made by the industrial sector in reducing emissions.

In the residential sector, no effective regulations exists requiring households, the player vested with primary control, to reduce CO_2 emissions. Thus there is no player with a strong incentive to cut CO_2 emissions except, it might be argued at a stretch, the government itself in that it has ratified the Kyoto Protocol and promised to abide by it. In the commercial and transportation sectors, there is a highly complex interaction of players, many of which do not necessarily possess strong incentives. With so many different players monitoring is difficult, and a regulatory approach is not well suited to these two complex sectors, where in many cases a player has little incentive to reduce CO_2 emissions despite being primarily in control. These structural observations would seem to account for the fact that the traditional approach with the central role of regulation does not appear to be working very well in the residential, commercial, and transportation sectors.

The behavior of consumers is of the utmost important. However, not only do they lack incentives; they are also hampered by a dearth of information on efficient devices. Even when they do possess such information, they frequently lack the ability to make proper judgements and have neither the capacity nor financial resources to purchase such devices and put them to appropriate use.

Table 1-3. Relationship between Emissions Sector and Players in Control

		Control capacity	Emissions sector			
			Industrial	Residential	Commercial	Transportation
Players in control	Industrial	High	Primary (strong)	Secondary (weak)	Secondary (weak) + Own emissions: Primary (weak)	Secondary (weak) + Own emissions: Primary (weak)
	Residential	Low		Primary (weak)		Own emissions: Primary (weak)
	Commercial	High			Primary (strong)	Own emissions: Primary (weak)
	Transportation	High			Own emissions: Primary (weak)	Primary (strong)
	Government	High	Secondary (strong)	Secondary (strong)	Secondary (strong)	Secondary (strong)

Note: Notations in brackets indicate strength of incentives to reduce greenhouse gas emissions.
Sources: Compiled by DBJ.

price level, for outcomes vary depending on the method of measurement employed. Generally speaking, energy consumption for essential purposes displays little price elasticity, and a rise in price does not result in that much of a decline in short-term volume of demand.

In fields like this where the primary player in control is unable to exercise that control effectively, a sensible approach would be to efficiently harness the capacity of manufacturers, the secondary players in control. That means providing assemblers, which can control product performance, choice of materials, and so forth, with ongoing positive incentives[17] to reduce emissions at the materials production stage while boosting energy-saving performance at the usage stage. It also means encouraging proper information disclosure. Such extra effort often leads to increased costs. If negative incentives are employed, such as regulations and fines, it may prove impossible to completely prevent businesses that dodge the regulations from making a profit, with the result that honest companies end up losing out. The sensible thing would be to lure manufacturers in the right direction with positive incentives designed to reward them fairly for any extra effort to make a long-term contribution to the fight against global warming.

There are instances of pioneering manufacturers dramatically reducing overall emissions during the product life cycle, including the usage/consumption stage. A case in point is the digital photocopier in Fig. 1-8. Digital photocopiers are not subject to Top Runner standards. But in this case the manufacturer decided to cut lifecycle emissions of its own accord with the goal of obtaining Type III eco-label certification.[18] As well as achieving a 70% cut in emissions at the usage/consumption stage, which accounted for the biggest chunk of lifecycle CO_2 emissions, it also reduced emissions at the materials production stage by over 30%. It thus succeeded in reducing overall emissions by 60% compared to conventional models. It has been even more zealous about cutting emissions at the product manufacture stage than at the usage stage; in the present case, it achieved a 20% reduction. The fact is that, generally speaking, industry is barely managing to keep emissions at the manufacturing stage in check, when they might actually be expected to rise due to the proliferation in functional and ecological requirements facing products today. Reductions at the product manufacturing stage equal less than 2% of those achieved at the usage/consumption stage. Virtually all the reductions thus belong to the

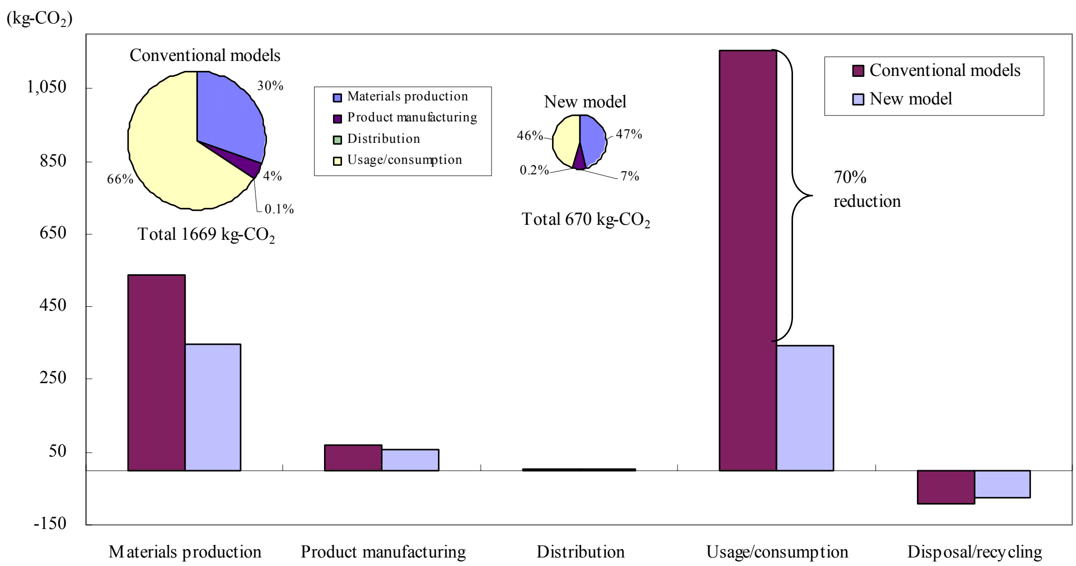


Figure 1-8. Improved CO_2 Emissions in a Digital Photocopier

Sources: Compiled by DBJ from Canon Inc., *Sustainability Report 2003: The Case of the imageRUNNERiR3300.*

[17] Incentives, that is, that function as a carrot, to use the familiar metaphor of the carrot and the stick.

[18] See Chapter II.

usage/consumption stage; achieving quantitatively significant reductions at the product manufacturing stage appears to be tremendously difficult. This example is highly thought-provoking in that it suggests where manufacturers can most effectively concentrate their management resources. Moreover, this fact would never have come to light if a pioneering manufacturer had not invested extra money and labor in processing data and then released them.

1-4. Difficulty of Cutting Emissions at the Manufacturing Stage and Importance of Lifecycle Emissions Analysis

Steps taken today to cut CO_2 emissions at the manufacturing stage often prove fairly expensive, in part because considerable progress has already been made on this front since the oil shock. Fig. 1-9 gives estimates of the unit cost of reducing CO_2 emissions based on data pertaining to the electrical and electronic industry available, for example, in follow-up documentation on voluntary action plans. Such data are not generally available to the public. A small circle as far as possible to the upper left-hand side of the graph would indicate a minimal investment resulting in a large reduction in emissions at a low unit cost. But no such cases are to be found. Conversely, a large circle to the lower right indicates a large investment resulting in a small reduction in emissions at a high unit cost. That may seem unappealing, but there are a fair number of such cases nonetheless. According to this set of estimates, the average unit price of reducing emissions is around ¥7,300/CO_2 ton,[19] which tentatively works out to 10-20 times what the cost is in the developing world. Other industries too find themselves having to resort to measures with high unit costs, which may range from ¥10,000 to over ¥100,000/CO_2 ton.

In the Seventh Eco-management Survey conducted by the Nihon Keizai Shimbun, forecasts of what the unit cost of cutting emissions per CO_2 ton would be in FY 2010 averaged ¥90,900 among the 206 companies from which responses were received. The average unit cost per company varied widely between industries, from a low of ¥10,300 for electric power to ¥187,600 for machinery, though in all cases the

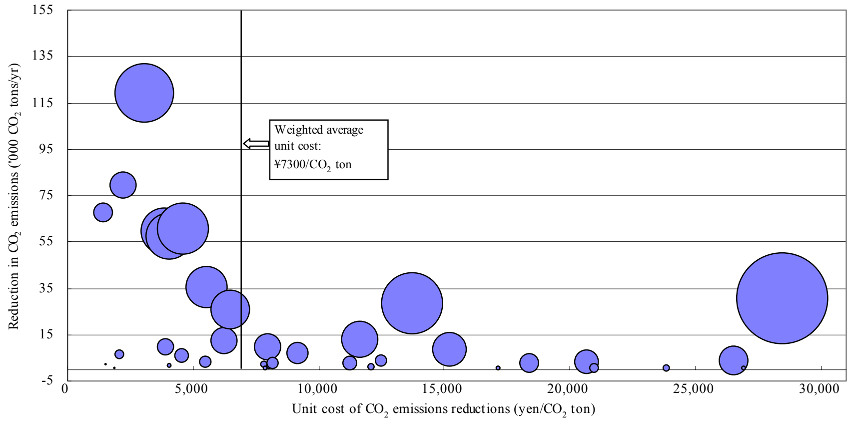


Figure 1-9. Investment in Reducing CO_2 Emissions by the Electrical and Electronic Industry

Notes:
1. Size of circle represents amount of investment (in millions of yen).
2. Unit cost of reductions was estimated assuming three years to recover investment, except in the case of strengthened management procedures, when a two-year period to recover investment was assumed.
3. In certain cases unit cost of reductions was estimated at over ¥100,000. However, all investments with an estimated unit cost of over ¥30,000 are omitted, the equivalent of 16,000 tons in reductions, or 2% of the total.
4. Investment in the two fiscal years 2001-2002 totaled ¥43 billion, with emissions reduced by roughly 680,000 CO_2 tons per year.
5. Compiled by DBJ from FY 2001 and 2002 follow-up documentation on voluntary action plans being pursued in the electrical and electronic industry.

[19] Roughly US\$70/CO_2

amount cited was fairly high. This confirms that cutting CO_2 emissions at the manufacturing stage is a very expensive prospect in Japan. Compare the situation in Europe, where companies can easily achieve their targets by pursuing measures with a unit cost of less than ¥2,500,[20] or in the developing world, where cutting emissions has a unit cost of ¥400-800.

Table 1-4. Cost of Reducing CO_2 Emissions in Major Industries, FY 2010

Industry	Average cost of reductions per company (yen/CO_2 ton)	
		No. of companies responding
Machinery	187,600	18
Pharmaceuticals	175,200	8
Automobiles/automobile parts	158,600	17
Electrical equipment	99,300	61
Pulp and paper	64,000	6
Chemicals	54,800	30
Steel	41,500	6
Petroleum	22,000	1
Gas	15,500	3
Electric power	10,300	7
Total	90,900	206
	(incl. electrical power)	

Sources: Excerpted from the Seventh Eco-management Survey (*Nikkei Sangyo Shimbun*, Dec. 16, 2003), (2) "CO_2 emissions, reduction costs, and projected purchase price of emissions rights in major industries, FY 2010"

In some cases CO_2 emissions may be reduced dramatically over the course of the whole product life cycle, yet emissions at the manufacturing stage take a massive leap. A classic example is provided in Fig. 1-10, which compares liquid crystal displays and CRT[21] monitors. In the case of liquid crystal displays, as with the new model of photocopier mentioned above, emissions at the usage stage lowered by 70%, resulting in a total emissions reduction of an estimated 45% over the whole course of the product life cycle. But there is one big difference from the photocopier: emissions at the materials production and product manufacturing stages jump a whopping 122% to over twice those associated with CRT monitors. At the manufacturing stage in particular, emissions jump more than sixfold in the case of a liquid crystal display. Because of increased production of liquid crystal displays, along with other factors, CO_2 emissions generated at the manufacturing stage by the companies affiliated with the four big electronic and electrical industry associations had as of FY 2002 risen 28% over 1990.[22] It is estimated that as of 2003 76% of the personal computers in use in Japan had liquid crystal displays. If they had all had CRT monitors instead, power demand would have increased by an estimated 3 billion kWh or

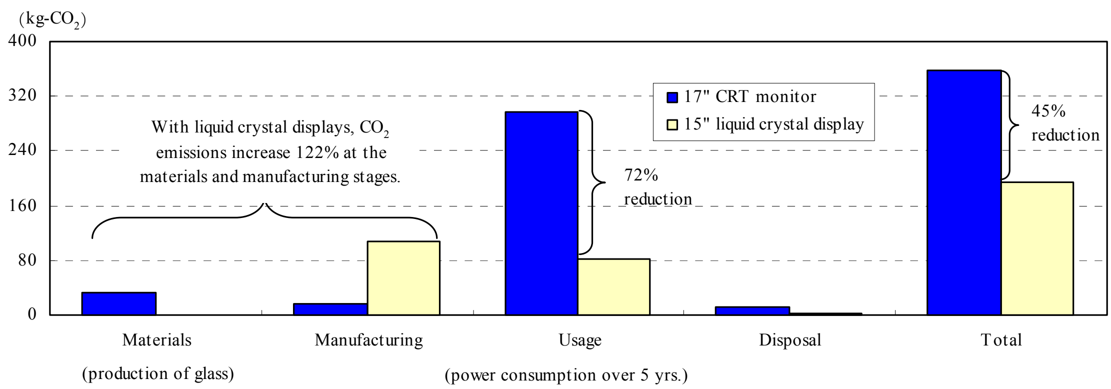


Figure 1-10. Lifecycle CO_2 Emissions for Liquid Crystal Displays and CRT Monitors

Sources: Compiled by DBJ from Association for the Promotion of Machine Systems and Electronic Industries Association of Japan, *Research Survey Report on Environmental Impact and Recycling of Liquid Crystal Displays* (March 2000).

[20] See for example Kornelis Blok, David de Jager, and Chis Hendriks (2001), "Economic Evaluation of Sectoral Emission Reduction Objectives for Climate Change" http://www.europa.eu.int/comm/environment/enveco/climate_change/sectoral_objectives.htm

[21] Cathode ray tube.

[22] Handout distributed at Session 3 of the Working Group on Electronics, Electrical Equipment, and Industrial Machinery Etc. (Joint Follow-up Subcommittee on Voluntary Action Plans on the Environment, a joint subcommittee of the Industrial Structure Council and Advisory Committee for Natural Resources and Energy, Ministry of Economy, Trade and Industry), Feb. 10, 2004.

the equivalent of two one-million-kW nuclear power stations, enough electricity for a million households.[23] Increased ownership of items like liquid crystal displays is in the best interests of society as a whole, yet the current approach, whereby the industrial and commercial/residential sectors take action in isolation from one another, could actually end up discouraging production of such devices.

If reducing emissions at the usage stage were all that mattered, then there would be no need to conduct an LCA. Companies could simply focus exclusively on the usage stage and take the necessary action. But the fact is that the situation differs greatly from device to device, and a significant level of emissions is not necessarily confined to the usage stage alone. As shown in Fig. 1-11, Konica Minolta is an enthusiastic practitioner of the LCA. It conducts LCAs for all its major products and releases the information so obtained. We cannot reproduce this here in full, but the results of the company's estimates at least should prove highly instructive. With certain items, such as automatic color film processors, the lion's share of emissions are generated at the usage stage, but then there are other items where materials production plays a big role, such as film cameras, digital cameras, and film-in single-use cameras. In the case of plastic lenses for CD products and color negative film, the processing stage is a major source of emissions.

In the case of a notebook PC, combined emissions at the materials production and product manufacturing stages actually exceed those at the usage stage, as shown in Fig. 1-12 The main reason for this is the use of components such as liquid crystal panels that have a large CO_2 emissions load at the manufacturing stage. In instances like this, action focusing on product manufacture and choice of materials should prove effective.

Thus the stage on which a company should primarily focus in the quest to reduce emissions varies depending on the product. That makes it crucial to conduct an LCA on each item and be aware of what stage is most important in order to be able to implement effective, efficient

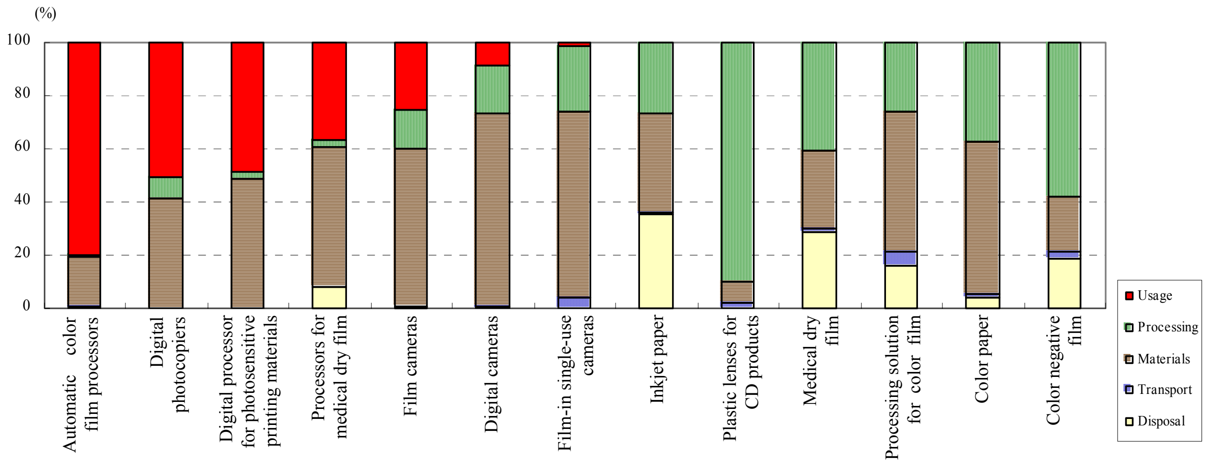


Figure 1-11. CO_2 Emissions at Each Stage of the Life Cycle by Product Type: The Case of Konica Minolta

Sources: Compiled by DBJ from Konica Minolta Holdings, Inc. data.

[23] According to Association for the Promotion of Machine Systems and Electronic Industries Association of Japan, *Research Survey Report on Environmental Impact and Recycling of Liquid Crystal Displays*. March 2000.

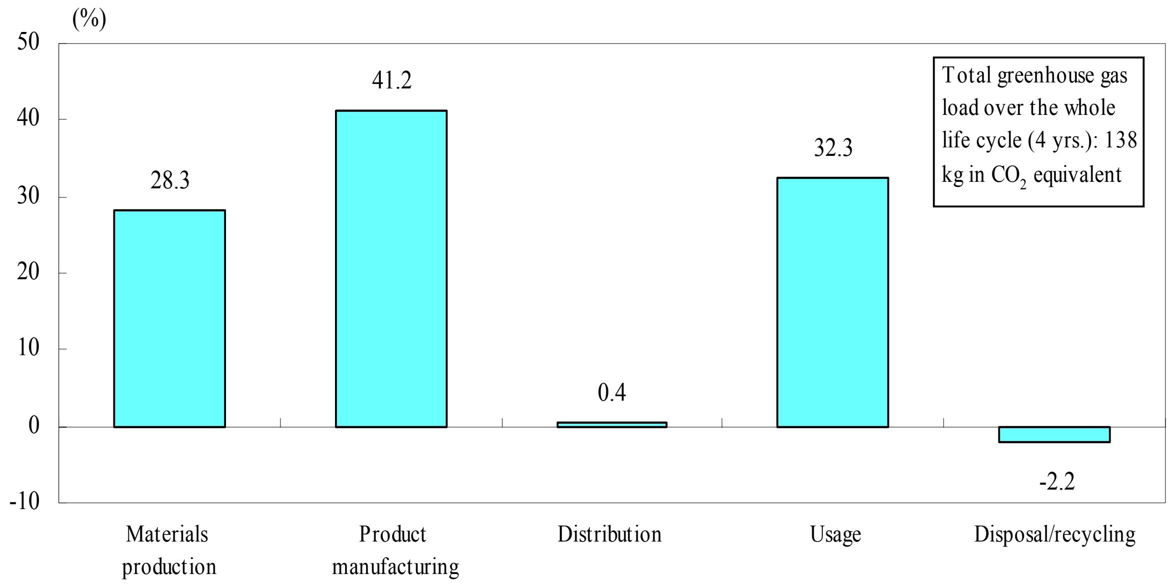


Figure 1-12. Percentage of CO_2 Emissions Generated at Each Stage of the Life Cycle of a Notebook PC

Sources: Compiled by DBJ from Fujitsu Limited, FMV-718NU4/N EcoLeaf Product Environmental Information Sheet No. AS-03-001.

measures. Preferably there should be a system of appropriate incentives to that end. If there are considerable emissions at, say, the materials production or disposal stage, which are today largely overlooked, then incentives that encourage, for example, the use of materials that entail lower emissions should be offered in an appropriate form to the player entitled to make such choices. Positive incentives that reward companies for grappling seriously with the challenge constitute an effective means of encouraging them to make an extra effort in the interests of society as a whole. An approach that relies on fines and regulations could end up placing companies that make a serious effort at a disadvantage.[24]

[24] In order for fines and regulations to work effectively, objective data must be available and easy to monitor, and companies that engage in abuses must be appropriately punished. LCAs are still only just starting to gain currency, and not all companies have the means to implement them. Moreover, if a company makes the results of an LCA look better than they really are by omitting key data or failing to gather data properly, there is no easy way for an outside party to conduct an accurate check and set matters straight. Given this state of affairs, a punitive approach is not likely to succeed.

1-5. Progress of LCA Efforts in Japan

Let us review the progress of LCA efforts among Japanese companies, turning to the Findings of the 2002 Survey of Environmentally Friendly Corporate Activities published by the Ministry of the Environment. This survey, to which 2,781 companies nationwide responded, is the most extensive of its type in Japan. Options (1) "We release the results" and (2) "We do not release the results as we are still at the implementation/study stage" may be taken to indicate that the company in question conducts LCAs in some form or another. On this evidence, it appears that roughly half of companies with sales of over ¥500 billion conduct LCAs in some form or another. However, only 154 of the responding firms had sales of over ¥500 billion; that creates doubts about how representative this sample is. Only a small percentage of firms with sales of under ¥500 billion conduct LCAs, judging not just from the aforementioned Options (1) and (2) but from (5) as well: "We are taking no particular action." It is thus fair to conclude that a cross-section of companies, albeit most of them large, have begun to implement LCAs.

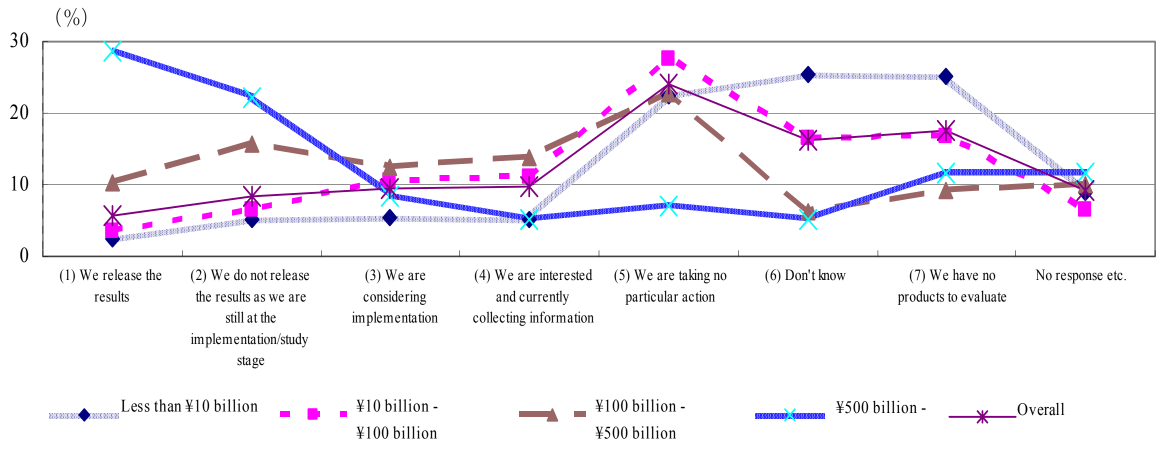


Figure 1-13. Corporate Implementation of Product LCAs, by Sales Volume

Note: A total of 2,781 companies responded, of which 154 had sales of over ¥500 billion.
Sources: Compiled by DBJ based on data from Ministry of the Environment, *Findings of the 2002 Survey of Environmentally Friendly Corporate Activities* (July 2003).

Next we review the question of what specific action companies are taking in the LCA field based on recent articles in the newspapers. Table 1-5 summarizes the main reports on corporate action in the LCA field that have appeared in the media, classifying these efforts by industry and sorting them into five stages: implementation, information disclosure, ecolabeling, systems, and applications. Generally speaking, the first stage involves implementing an LCA on an experimental basis and referring to the findings in the conduct of in-house environmental management. When the LCA information is of high enough quality for external release, and releasing it makes sense, the company will make it available to the outside. The next stage entails obtaining Type III ecolabel[25] certification, if it makes sense to incur the additional costs of obtaining outside certification for a product so that it can publicly display the label. As the number of such products proliferates, the company will put in place systems for gathering and releasing LCA data. A further step will be the application of LCA data to the company's environmental accounting procedures and such. Although matters do not necessarily proceed in exactly this order, it is reasonable to assume as a rough principle that a company engaged in activities falling into the categories of systems and applications is further on in its LCA efforts than is one that is merely at the implementation stage.

What about the progress of LCA efforts within particular industries? The electrical equipment, general equipment, chemicals, and transport equipment industries are all engaged in LCA efforts in the categories of Type III ecolabeling, systems, and applications. Electrical equipment manufacturers have undertaken an impressive array of pioneering programs. These include developing a yardstick of eco-efficiency known as Factor X by using LCA data;[26] factoring into environmental accounting procedures the benefits of alleviating environmental load as

[25] A label that shows environmental impact in quantitative terms based on an LCA.

[26] Factor X is a means of evaluating eco-friendliness. Into the numerator is plugged a figure representing the affluence and ease of use resulting from enhanced performance and function; into the denominator is plugged environmental load data obtained from LCAs and the like. A base year is set, and the fluctuation in eco-efficiency is determined by observing how the ratio has changed. This method of assessing eco-friendliness is a refined version of Factor Four, a formula for doubling affluence and halving the environmental load advocated by Dr. Ernst von Weizsacker of the Wuppertal Institute in Germany in the early 1990s. Calculating Factor X has been made possible by the aggregation of LCA data.

quantitatively calculated using LCA methods; and adopting LCC,[27] which enables one to convert to a monetary value the environmental load of a product or service. If, for example, a company adopts LCC, a product's environmental load can be expressed as a monetary value that can be compared with, say, manufacturing costs. That, it is hoped, will help in determining the overall costs of environmental measures, developing eco-friendly products, and making decisions with respect to investments in environmental conservation. Certain manufacturers in the general equipment and chemical sectors have taken steps to disclose information on environmental load by for example obtaining Type III ecolabel certification. Progress is likewise being made in the transport equipment industry. A system is being developed to facilitate the design of more eco-friendly vehicles by creating a special database with the cooperation of parts suppliers. This database incorporates information on fuel consumption, exhaust emissions, and noise produced by all models of car during the usage stage, as well as recyclability at the disposal stage and carbon dioxide (CO_2) emissions at all stages. Another system is also being developed, this one for managing the environmental load associated with all aspects of business operations. As for other industries, most media reports are of companies starting to implement LCAs, which constitutes the prior stage to systems and applications; companies in these sectors have thus not yet made that much headway in harnessing LCAs for other applications. As this brief survey shows, different industries and firms have undertaken a diverse range of actions in the LCA field. The cases covered in the media no doubt constitute the mere tip of the iceberg: it is fair to assume that the actual array of efforts being pursued is far broader.

[27] LCC (life cycle costing) is a method of expressing the environmental load of a product in monetary terms. The things analyzed are the same as in the case of an LCA; the difference is that, while an LCA expresses the environmental load in quantitative terms, the LCC represents it as a monetary value.

Table 1-5. Major Newspaper Reports on Recent Corporate Action in the LCA Field

Industry	Company	Description	Imple-mentation	Informa-tion dis-closure	Eco-labeling	Systems	Applica-tions
Electrical equipment	Hitachi, Matsushita Electric Industrial, Mitsubishi Electric, Fujitsu	Begin formulating standards for Factor X, a yardstick of eco-efficiency that adopts an LCA perspective.					○
	Sony	Factors into environmental accounting procedures the benefits of alleviating the environmental load from recycling home appliances.					○
	NEC	Starts offering Internet service for retrieving environ-mental information that incorporates LCA results.					○
	Fujitsu	Implements LCC (life cycle costing) on notebook PCs.					○
		Obtains the first ever EcoLeaf certification for a PC.			○		
	Pioneer	Sets up a system that pools LCA data so that it can be shared on line by the firm's product design arms.				○	
	Matsushita Electric Industrial	Calculates the total environmental load of its main products and releases tentative LCA data results.		○			
General equipment	Canon	Sets company-wide environmental management targets based on LCA data.					○
		Obtains EcoLeaf system certification in four fields.				○	
		Becomes the first company certified to implement EcoLeaf certification procedures exclusively in house.			○		
	Ebara	Launches a program for gauging CO_2 emissions using LCA methods and recycling used pumps.					○
	Brother Industries	Obtains the first ever EcoLeaf certification for a home fax machine.			○		
	Daikin Industries	Brings in LCA assessments for all models of air conditioner, the firm's flagship product.	○				
Transport equip-ment	Toyota	Develops the new Eco-VAS system and brings in LCAs for all car models to be developed in 2005 and beyond.				○	
	Honda	Gets the Honda LCA System fully up and running as a means of gauging the environmental load of a car over its life cycle.				○	
Chemicals	Konica Minolta	Begins trading of emissions rights between group firms based on their volume of CO_2 emissions as calculated using LCA methods.					○
		Obtains system certification allowing it to implement EcoLeaf certification procedures exclusively in house.				○	
		Obtains the first ever EcoLeaf certification for a photocopier, film-in single-use camera, and film camera.			○		
	Maruzen Petrochemi-cal	Obtains EPD certification for chemical products.			○		
	Fuji Photo Film	Obtains the first ever EcoLeaf certification for a digital camera.			○		
Other	Toshiba Engineering	Launches LCA proxy service using LCA software.				○	
	Takara Shuzo	Obtains the first ever EPD certification for a season-ing.			○		
	Dai Nippon Printing	Obtains EPD certification for a dye-sublimation thermal-transfer ink ribbon.			○		
	NTT East	Releases results of LCAs conducted on communica-tion networks etc.		○			
	House Foods	Verifies benefits of lighter packaging using LCA methods.	○				
	Shimizu	Adopts LCA methods in designing buildings.	○				
	Kawasaki Heavy Industries	Conducts LCAs on major models of carriage manu-factured at its rolling stock plant.	○				

Sources: Compiled by DBJ from newspaper reports for 2002-2003, company materials, etc.

II The State of LCA Today and Cases of LCA in Use

2-1. What Is LCA?

Chapter I looked at the importance of LCA in the fight against global warming and surveyed what progress companies are making in the LCA field. Chapter II steps away from the issue of global warming and delves further into the question of the state of LCA today and how LCA is actually being used.

LCA is a tool for quantitatively assessing and interpreting, for a specific purpose, the environmental impact of a product or service over the complete course of its life cycle from the moment it comes into being until it is discarded -- in other words, from resource extraction through disposal and recycling. By conducting an LCA, a company can quantitatively comprehend the environmental load imposed at each stage of the life cycle not just by a specific product or service, but in certain cases by all its business operations. A knowledge of what type of environmental load occurs to what degree at each stage of the life cycle enables the company to determine, when manufacturing a product, the stage at what improvements can most effectively be made in order to alleviate the environmental load overall. This allows the company to implement environmental impact management in efficient fashion when designing a product or making business decisions.

The LCA is believed to have originated in a study conducted at the Midwest Research Institute in the United States in 1969 that was designed to assess the environmental impact of Coca-Cola's beverage packaging. This was the first time that the idea of quantitatively assessing the environmental impact of something over the course of its life cycle was applied. This study assessed the environmental load imposed by returnable bottles[28] as opposed to disposable containers and compared the results. At that time littering was a problem in the US because people would indiscriminately discard used beverage containers everywhere, and reducing garbage had become an important policy objective. In the state of Oregon a 1969 bill prohibiting the sale of beverages in non-reusable bottles was defeated in the face of opposition by the beverage indus-

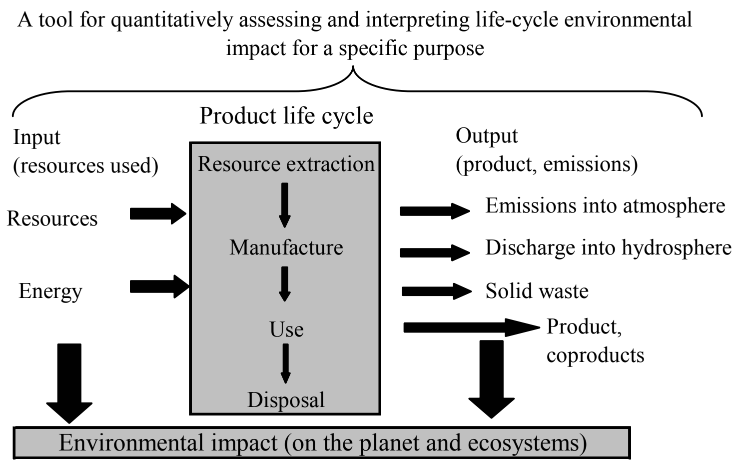


Figure 2-1. What Is LCA?

Sources: Compiled by DBJ from materials from the Seminar on LCA Database Use organized by the Japan Environmental Management Association for Industry.

[28] A bottle that has been used, returned, and washed and is then refilled.

try, but then in 1971, following the above study, a similar bill passed.[29] This ushered in the world's first bottle deposit system. The Oregon Bottle Bill was primarily designed to reduce garbage, but it also had the goal of encouraging the spread of returnable bottles. After all, returnable bottles are more conducive to saving energy and natural resources than are disposable containers, since they can be collected, washed, and refilled repeatedly. The returnable bottle is a case in point of government policy incorporating life-cycle thinking.

LCA research made further headway in the US thanks to the Society of Environmental Toxicology and Chemistry (SETAC), which was established in 1972 as a forum through which various environmental scientists (biologists, chemists, toxicologists, etc.) and corporate managers could conduct interdisciplinary studies. SETAC is a non-profit, public-interest organization with balanced involvement by industry, academia, and government. It has contributed to the progress of LCA research by setting up a committee of experts with LCA knowledge and publishing an information magazine on LCA issues.

In Europe LCA research commenced around the same time as in the US. In 1972, in the United Kingdom, an LCA-type approach was used to make a rough assessment of the total energy expended in manufacturing beverage containers from materials such as glass, plastic, steel, and aluminum. In 1979 a methodology was unveiled that enabled this assessment technique to be applied to a wide range of materials. In 1985 the European Commission brought into force the Liquid Food Container Directive, which required companies to monitor consumption of energy and raw materials and generation of solid waste by liquid food containers. This directive obliging companies to implement life-cycle resource management helped foster the spread of an LCA-type approach among European firms. In 1990, building on a methodology and database developed by the Swiss Agency for the Environment, Forests and Landscape (BUWAL), computer software was developed and put to use in product development at co-ops and the like. Meanwhile, in the Netherlands, the Centre of Environmental Science at Leiden University unveiled a Dutch version of an LCA methodology manual, complete with the associated computer software, around 1991.

The first reported instance of an LCA-type approach being employed in Japan was in 1981, when the Chemical Economy Research Institute implemented an analysis of the energy-saving benefits to be gained from adopting new materials. This analysis compared new materials such as plastics and fine ceramics with conventional industrial materials by quantitatively assessing the life-cycle energy consumption of both. But little subsequent LCA-type research on product environmental load was to be conducted in Japan until the 1990s. On the other hand, in the late 1980s, studies began being conducted in the nuclear energy field on the costs and environmental load imposed by generating plants over the whole course of their life cycle. One independent development in Japan during the 1980s was the progress of research on CO_2 emissions from different industries, including their spillover effect; this made use of input-output tables. In 1992 the first LCA-type study organized by the government was carried out, "A Preliminary Study on Assessing the Load on the Environment." Implemented under the direction of the Ministry of the Environment, this study summarized the state of LCA in Japan at the time. Nonetheless, by the latter half of 1993, when work began on establishing standards for ISO14040, which defines the principles and framework for LCA, it became clear that Japan had fallen vastly behind the European countries with their advanced databases and arsenal of techniques. In 1995 the LCA Japan Forum was established as a clearinghouse for discussion of LCA issues by LCA researchers in industry and academia. Thus began serious discussions on the databases and standardized methods required to underpin LCA implementation. In June 1997 a policy statement was released summing up the outcome of these discussions. This contained the following five recommendations:

(1) Industry should actively adopt an LCA approach: determine the soundness of product plans, assess the need for product development projects, set priorities for taking

[29] The Oregon Bottle Bill.

eco-friendly measures at the product design stage and when upgrading the production line, and so forth.

(2) If the LCA is to assume its proper role as one means of sustainable development, it is essential that it achieve recognition as an unbiased, dependable tool for assessing eco-friendly concerns; that will require developing LCA methods and constructing LCA databases.

(3) If LCA is to come into widespread use, well-stocked databases of various types will need to be developed, which will require industry to make available reliable databases and actively release LCA results. To that end an umbrella organization should be set up to oversee a standard database for Japan.

(4) LCA methods are still at the developmental stage; no comprehensive assessment techniques have yet been established. Therefore caution is required when conducting an LCA in order, say, to make a comparative assessment of the environmental impact of substitute materials or substitute products. Prioritization of environmental factors and issues will vary depending on the specific society, place, and time, for which reason it must be recognized that there is a danger inherent in relying on LCA methods alone as a basis for decision-making.

(5) Adoption of LCA methods by industry is not enough on its own. People at all levels, including the general public, need to adopt life-cycle thinking and reassess their own lifestyles.

In response, the Ministry of Economy, Trade and Industry launched Phase I of the Product Life Cycle Environmental Impact Assessment Technology Development Project (generally known as the LCA Project). This five-year program (1998-2002) was designed to lay the foundations for LCA technology in Japan. The outcomes from this phase of the project include not merely putting together an LCA database consisting of some 550 items of inventory data,[30] but also formulating a proposal for a life-cycle impact assessment method based on endpoint modeling. Japanese companies have, it is claimed, now been able to catch up to their European and American counterparts in the level of their LCA activities.

In 2001 the European Commission released a green paper on integrated product policy (IPP),[31] which is designed to minimize the environmental impact of products at every stage of the life cycle. Although IPP has not yet borne fruit in the form of concrete policy steps, European LCA research has surged ahead on a wide range of fronts now that Europe has set a clear direction for its LCA policies. The Johannesburg Summit Implementation Programme, which was published as the accomplishments of the 2002 World Summit on Sustainable Development (WSSD),[32] or Johannesburg Summit, calls where appropriate for implementation of life cycle analysis and identification of national indicators for measuring progress, this in order to promote development of a ten-year framework of programs to accelerate the shift towards sustainable production and consumption. It was expressly stipulated that LCA would continue to be pursued within an international framework. That same year the decision was made to adopt the Type III ecolabel -- a label that lists environmental information in quantitative terms based on an LCA -- as an international standard under ISO14025 by the end of 2006; meanwhile, the Japan Environmental Management Association for Industry began administering Japan's first Type III ecolabel, the EcoLeaf. In 2003 the Ministry of Economy, Trade and Industry launched Phase II of the LCA Project with the goal of, among other things, database expansion.

[30] Inventory data are data on inputs in the form of materials and energy and outputs in the form of end products and environmental load at each stage in the life cycle of the product or service subject to the LCA.

[31] Integrated product policy (IPP) is a policy that demands the most effective action for minimizing environmental load over the course of the life cycle. It requires comprehensive measures at each stage of the product life cycle -- measures harnessing such policy techniques as economic tools, eco-labeling, and product design.

[32] The World Summit on Sustainable Development (WSSD) was a global conference on sustainable development dedicated to the basic themes of "Economic Growth and Equity," "Conserving Natural Resources and the Environment," and "Social Development." Government officials, NGO personnel, and media representatives from 191 countries attended -- a total of more than 21,000 people.

Table 2-1. History of LCA

Year	Country/entity	Details
1969	US	Midwest Research Institute conducts environmental impact assessment of Coca-Cola's beverage packaging.
1972	UK	Assessment of energy expended in manufacturing beverage containers.
1979	USA	Society of Environmental Toxicology and Chemistry (SETAC) established. An independent, non-profit body, SETAC takes an interdisciplinary approach to developing LCA methods, with balanced involvement by industry, academia, and government.
1981	Japan	Chemical Economy Research Institute conducts quantitative analysis comparing energy consumption of new and conventional materials.
1992	Japan	Ministry of the Environment conducts Preliminary Study on Assessing the Load on the Environment.
1993	ISO	Work begins on establishing standards for ISO14040, which defines the principles and framework for LCA.
1995	Japan	LCA Japan Forum established as a clearinghouse for discussion of LCA issues by LCA researchers in industry and academia. (It presents a set of policy recommendations in 1997.)
1997	ISO	ISO14040 published.
1998	Japan	Ministry of Economy, Trade and Industry launches Phase I (1998-2002) of the Product Life Cycle Environmental Impact Assessment Technology Development Project (LCA Project).
	Sweden	Begins administering EPD.
1999	GEDnet	Network of Type III ecolabel certification bodies launched.
2000	ISO	Releases Type III ecolabel technology report (ISO/TR14025).
2001	EU	Releases green paper on Integrated Product Policy (IPP).
2002	World	World Summit on Sustainable Development (WSSD) convenes. Basic program defines LCA as having a role to play in the shift towards sustainable production and consumption.
	ISO	Decides to adopt an international standard of Type III ecolabel (official publication slated for Dec. 2006).
	Japan	Begins administering EcoLeaf.
2003	Japan	Ministry of Economy, Trade and Industry launches Phase II (2003-2006) of the LCA Project.

Sources: Compiled by DBJ from the Society of Non-Traditional Technology and Ecomaterials Forum (eds.), *All about LCA* etc.

2-2. Types of Ecolabels

An ecolabel is any written description, symbol, design, or diagram, whether appearing on a package label or in a user's manual, technical report, advertising, publicity materials, etc., that conveys to the purchaser information about the environmental aspects of a product or service. Ecolabels are classified into three types because of differences in the type of environmental data that they provide and so forth. Of late the Type III ecolabel, which shows environmental impact in quantitative terms based on an LCA, has become the focus of much interest, for there is a growing awareness of the importance of quantitatively managing the environmental load at each stage -- materials production, assembly, transportation, use, and so forth.

A Type I ecolabel is a label that a company is permitted to use with respect to a product or service that is found to meet certain criteria set by a neutral, impartial third-party agency. A Type 1 label makes comparison easy, since you can determine whether the item in question has a small or large environmental impact based on whether or not it bears the label, which certifies conformity with certain standards. But the Type 1 ecolabel has a drawback: it does not allow you to compare the environmental load of two products that both carry the label, because it merely indicates that an item clears a certain level. Japan's sole Type I ecolabel is the Eco Mark,[33] which conforms with ISO standards (ISO14024). Eco Mark eligibility is assessed by a third-party

[33] The Eco Mark is administered by the Japan Environment Association. It is a Type I ecolabel awarded to products certified by a third party as being conducive to environmental conservation because they meet certain conditions, such as being highly beneficial in helping to preserve the environment. For example, the environmental load that they impose over their life cycle might be smaller than for comparable products, or using them may alleviate the load on the environment imposed by other factors.

agency using a set of certification criteria embracing all stages of the life cycle from product manufacture through disposal. As of September 2003, 5,618 products in 59 categories had obtained Eco Mark certification. Products made from recycled materials predominate: items of recycled plastic top the list -- 985 items in total -- followed by apparel made from recycled polyethylene terephthalate resin -- 735 items in total. Further progress is set to be made in promoting cross-certification[34] with overseas labels and strengthening coordination with other labels, such as Type III ecolabels.

A Type II ecolabel is self-declared. The company establishes its own environmental standards and determines for itself whether a particular product meets them. This type of ecolabel is used for external promotion purposes, appearing in pamphlets and other materials or being applied as an actual label. One example is Toshiba's Global Environment Mark, which identifies products, services, technologies, and programs that alleviate environmental load, whether by conserving energy to reduce CO_2 emissions, recycling, or reducing use of substances that put a burden on the environment. Another example is Fujitsu's Eco Symbol Mark, which is designed to get out the message about how hard the company is working to recycle, save energy, and employ eco-friendly materials. Such labels are awarded by the company itself in accordance with criteria that it sets in house; hence they involve relatively little expense, since there is no third party to pay, plus the authorization process is swift, since there is no need for outside certification. As with Type I ecolabels, an item either passes or fails; that makes it easy to compare a certified product with other items for environmental load. You can determine whether an item has a small or large environmental impact based on whether or not it bears the label.

Type II ecolabels differ from their Type I counterparts in that administration and certification are handled by the company releasing the information itself rather than by a third-party agency. Type II ecolabels thus tend to compare unfavorably to Type I ecolabels in terms of objectivity. Moreover, criteria for Type II labels vary from company to company, and whether a particular product is awarded a label or not is determined based on voluntary criteria set by the company itself on a subjective basis. That makes it difficult to compare different makes of product.

A Type III ecolabel shows environmental impact in quantitative terms based on an LCA. Its presence or absence is not meant to indicate that a particular item has a small or large environmental impact. Rather, the label provides objective data in a manner designed to enable direct comparison, and the consumer viewing it is left

Table 2-2. Types of Ecolabels

	Type I	Type II	Type III
Description	Label certifying compliance with environmental standards set by a third-party agency	Self-declared company label	Label showing environmental impact in quantitative terms based on an LCA
Administrated by…	Third-party agency	Releasing party	Third-party agency
International standard	Prescribed under ISO14024 (published Apr. 1, 1999)	Prescribed under ISO14021 (published Sept. 15, 1999)	Currently under discussion (ISO14025)
Environmental data provided	Essential items only	Items selected by releasing party	Quantitative environmental information on life cycle
Cases of implementation	Eco Mark (Japan) Energy Star (US) Blue Angel (Germany)	Global Environment Mark (Toshiba) Eco Symbol Mark (Fujitsu)	EcoLeaf (Japan) EPD (Sweden)

Sources: Compiled by DBJ from the web site of the Japan Environmental Management Association for Industry etc.

[34] For example, in the case of photocopiers there is partial cross certification with the Nordic Swan. Thus a photocopier that has obtained Eco Mark certification is exempted from screening for certain items that the Nordic Swan shares in common.

to decide for himself or herself the degree of environmental impact. Like Type I ecolabels, Type III ecolabels are administered by third-party agencies; this guarantees objectivity. Type I and II ecolabels indicate by their presence that the products carrying them clear specific criteria. But in the case of Type III ecolabels, the quantity of environmental information to be shown is so great that it will not all fit onto the product; data are therefore posted on a web site or the like. Typically, certified products carry a registered logo giving, say, a web address, and the consumer or whoever is referring to the label accesses that site to obtain the requisite information. International standards for Type I and II ecolabels have been formally issued by the ISO, but Type III ecolabels are currently only governed by ISOTR14025; the promulgation of an international standard will have to await official publication of ISO14025, which is slated for 2006. Use of Type III ecolabels is becoming rapidly more common, and the introduction of an official ISO standard can only be expected to increase the momentum.

2-3. EcoLeaf and EPD Compared

Type III ecolabels, then, give environmental information in quantitative terms based on an LCA. Japanese companies use mainly two kinds of Type III ecolabels: the EcoLeaf and the EPD (Environmental Product Declarations). A brief overview of these follows (Table 2-3).

The EcoLeaf, which is administered by the Japan Environmental Management Association for Industry, is a Type III ecolabel that focuses on widespread usability and comparability. System certification[35] is permitted as a prompt, economic way of obtaining EcoLeaf authorization: once a company acquires system certification, products need only pass testing by an inside auditor employed independently by the organization in order to be authorized to carry the label. This has several advantages. It allows a company to obtain EcoLeaf certification quickly and flexibly in step with its new product development and release schedule. It also makes the unit cost per certification fairly low if the company is going to be obtaining more than a certain number of certifications. The EcoLeaf program prescribes a set of standards, known as Product Specification Criteria (PSC), through agreement among the parties concerned. These standards govern gathering of data on inputs in the form of materials and energy and outputs in the form of end products and environmental load at each stage of the life cycle of the product or service in question; this is in order to guarantee comparability between products. In gathering LCA data, an important consideration is the data quality requirements: i.e., what type of data can be omitted (cut off), and to what extent is it permissible to use background data[36] not directly pertaining to the product. The EcoLeaf program prescribes no uniform standards in this regard; instead, separate standards are established for each PSC set. Data quality requirements vary widely depending on product category; this results from the belief that setting requirements by product better enables the formulation of appropriate rules. What the EcoLeaf program stresses is comparability. Discrepancies in the numbers within product

[35] Normally, obtaining EcoLeaf certification requires the following steps. The company planning to release the ecolabel formulates the label in line with LCA methods. The label is then screened by an outside auditor, following which an adjudication is made by an adjudication committee consisting of academics, LCA experts, consumers, and so forth. System certification enables a company issuing the ecolabel to have an internal auditor handle the job of screening it in place of an outside auditor, and exempts it from the need for adjudication by an adjudication committee. Awarding system certification involves screening the company to certify that it has in place the necessary systems for data collection etc. and runs them properly and efficiently. This screening is carried out in accordance with the Requirements for Product Environmental Data Collection Systems released under the EcoLeaf program. Once a company has system certification, it can quickly and economically obtain EcoLeaf certifications for large numbers of products of the same type. A company acquiring system certification must, depending on its size, pay a certification fee of anywhere between ¥1.6-2.7 million at the time certification. But once it is system-certified, it no longer has to pay a data screening fee to an outside auditor when obtaining EcoLeaf certification for a particular product using the certified systems. Thus, if it wishes to get large numbers of products EcoLeaf-certified, it can do so at a relatively lower cost per product.

[36] In an LCA, the term foreground data is used to refer to data pertaining directly to the product in question; the term background data is used to refer to data pertaining indirectly to the product in question, such as data on materials, electric power, fuel, and so forth. It is preferable that most foreground data be based on actual measurements.

categories are minimized by, for example, standardizing the principal basic units (specifying the numerical values) used for LCA data. The cost of EcoLeaf certification is relatively low, averaging around ¥300,000-500,000 per product, and the label has spread rapidly in the year and a half since it became available in 2002. So far 110 products have been certified.

EPD, which is administered by the Swedish Environmental Management Council, is a Type III ecolabel that focuses on internationality and reliability. The program is global in scope, being used to certify products and services in five countries: Sweden, Italy, Finland, Poland, and Japan. Three of those countries -- Sweden, Italy, and Japan -- have third-party certification agencies. The Japan Gas Appliances Inspection Association has been accredited by the Swedish

Table 2-3. EcoLeaf and EPD Compared

	EcoLeaf	EPD (Environmental Product Declarations)
Administering country	Japan	Sweden
Administering body	Japan Environmental Management Association for Industry	Swedish Environmental Management Council
Certifying body	Japan only Japan Environmental Management Association for Industry	Certified by 8 third-party agencies in Sweden, Italy, and Japan (1 agency in Japan: the Japan Gas Appliances Inspection Association)
Method of certification	Label certification, system certification	Product certification as per ISO/IEC Guide 65
LCA rules (assumptions upon which standards set for product use, scope of assessment, work process methods and conditions, methods of calculation, etc.)	Employs Product Specification Criteria (PSC)	Employs Product Specification Requirements (PSR)
Basic units	Standardized	Methods standardized for each product group within scope of PSR
Data quality	Separate cutoff (rule allowing omission of data on processes with negligible environmental impact) and data quality requirements (conditions governing percentage of data not specific to the product being certified that can be used) are established for each PSC set.	Items representing 1% or more of the environmental impact cannot be cut off. Data not pertaining specifically to the product must constitute less than 10% of total.
Country where registered	Japan	Sweden, Italy, Finland, Poland, Japan
No. of products registered (as of 31 January 2004)	110 (Japan: 110 representing 22 companies)	67 (Japan: 7 representing 3 companies)
Standard lead time for certification	Preparation, discussion, and approval of draft PSC: 2-4 mos. Preparation, verification, and approval of label: approx. 2 mos.	Preparation, discussion, and approval of draft PSR: 2-4 mos. Preparation, verification, and approval of label: approx. 2 mos. (In case of pre-certification, the PSR does not need approval. This reduces lead-time by 1-2 mos.)
Term of validity	Can be renewed every year (3 yrs. for system certification)	Can be renewed every 3 yrs. (every year in case of pre-certification)
Official language	Japanese (information available in English)	English (information available in Japanese)
Average cost of certification per product	Approx. ¥300,000-500,000	Approx. ¥600,000-800,000
Characteristics	Focuses on widespread usability and comparability	Focuses on internationality and reliability

Note: Pre-certification is a form of certification available under the EPD and similar programs as a way of speeding up the certification process. The assumption is that pre-certification will be upgraded to formal certification at some point. It enables a company to obtain certification for a limited one-year term even without formal PSR certification.

Sources: Compiled by DBJ from the web sites of the Japan Environmental Management Association for Industry and the Japan Gas Appliances Inspection Association (JIA), as well as from interviews.

Environmental Management Council as the certification agency for Japan. The EPD program is the first Type III ecolabel certification system to employ a product certification regime based on the ISO/IEC Guide 65.[37] Thus the screening agency to an extent guarantees the reliability and accuracy of the data used, as well as the conformity of the product, process, or service in question in so far as it has been able to verify it.[38] That has the advantage for the applicant of guaranteeing the reliability of the data released. But the data quality requirements are fairly stringent. Only items that represent less than 1% of the total index of life cycle impact are allowed to be omitted from the calculations (cut off); also, in order to enhance data reliability, data not pertaining specifically to the product being certified must constitute less than 10% of the total.

2-4. Japanese Action in the LCA Field

Table 2-4 provides an overview of action undertaken nationally by Japan in the LCA field.

In October 1995 -- by which point the country had fallen over a decade behind Europe and North America -- the LCA Japan Forum was launched. This served as a clearinghouse for discussion of LCA issues and the future of LCA by members of industry, academia, and government; it also acted as a hub for pooling and exchanging relevant information. As we saw in Section 2-1, in June 1997 the Forum released a policy statement that identified LCA as an effective means of conducting environmental assessments on products. The policy statement also underscored the need to construct reliable databases and develop environmental impact assessment tools if LCA was to come into widespread use in Japan. In response, in 1998 the Ministry of Economy, Trade and Industry launched a five-year national program, Phase I of the Product Life Cycle Environmental Impact Assessment Technology Development Project (generally known as the LCA Project). This was a truly massive project. The budget for Phase I of the LCA Project totaled ¥1.28 billion over five years. But the real cost was several times that amount, for the above figure does not include the personnel and other expenses incurred for the programs undertaken by the 54 industry associations that took part and cooperated. Nonetheless, the companies affiliated with the participating industry associations appear to have derived benefits from the project commensurate with the amount of money that they invested: they were able to absorb LCA knowledge, develop requisite skills, and so forth. Thus the project was implemented in very well thought out fashion such as to curtail net government expenditures.

Phase I of the LCA Project was executed with such objectives as (1) establishing LCA methods for shared use in Japan, (2) developing a public database accessible to anyone, and (3) developing a network system that ensures ease of data use etc. The outcomes included putting together a database consisting of some 550 items of inventory data, as well as formulating a proposal for a life-cycle impact assessment method based on endpoint modeling.

In the following year, FY 2003, Phase II of the LCA Project began. The main objectives of this phase are (1) promoting the widespread adoption of LCA methods in society by, e.g., applying them in regional policy, and (2) supporting private-sector firms in their independent efforts to build a sustainable socioeconomic system through the advancement of research on LCA products and on 3R[39]-LCA. Specifically, the goals are to compile a manual of regional LCA procedures, expand data and upgrade techniques of analysis, and create a standardized 3R-LCA assessment method and model. Phase II of the LCA Project is to run for three years, from FY 2003 through FY 2005, on an annual budget of approximately ¥300 million. It will involve participation by local governments and ordinary companies rather than industry associations.

[37] I.e., the ISO/IEC Guide 65 compiled by the ISO/IEC in 1996, General Requirements for Bodies Operating Product Certification Systems. This standardizes the requirements to which certifying agencies are to conform in order to ensure the soundness of the product certification process.

[38] In the case of system certification such as ISO14001, the screening agency guarantees the conformity of the environmental management system in question in so far as it has been able to verify it. However, the reliability of the products and data that constitute the output from the system lies outside the scope of the guarantee. See the ISO/IEC Guide 66-1996 etc.

[39] Reduce, Reuse, and Recycle

Table 2-4. Overview of the LCA Project

	LCA Project, Phase I	LCA Project, Phase II
Objectives	Establishing LCA methods for shared use in Japan Developing a public database Developing a network system that ensures ease of data use etc.	Promoting the widespread adoption of LCA methods in society Through LCA methods, supporting private-sector firms in their independent efforts to build a socioeconomic system with an environmentally-sound material cycle
Participants	54 industry association etc.	Mie, Chiba, and Iwate Prefectures, firms helping in gathering data, etc.
Duration	1998-2002	2003-2006
Themes	Gathering inventory data Designing specifications for an LCA database system Developing a life-cycle impact assessment method suitable for Japan based on endpoint modeling	Developing LCA methods for regional industry Promoting LCA research and development on downstream products Classifying venous data Increasing reliability and versatility of the life-cycle impact assessment method based on endpoint modeling
Outcomes (expectations)	Some 550 items of inventory data gathered Database compiled Proposal formulated for a Japanese version of life-cycle impact assessment method based on endpoint modeling	Compile manual of regional LCA procedures Expand data, upgrade techniques of analysis Create standardized 3R-LCA assessment method and model
Budget	Ministry of Economy, Trade and Industry - NEDO ¥1.28 billion (for 5 yrs.)	Ministry of Economy, Trade and Industry - NEDO Approx. ¥300 million (annually)

Note: Inventory data are data on inputs in the form of materials and energy and outputs in the form of end products and environmental load at each stage in the life cycle of the product or service subject to the LCA.

Sources: Compiled by DBJ from materials from the Seminar on LCA Database Use organized by the Japan Environmental Management Association for Industry.

2-5. Overview of the Database

The database compiled during Phase I of the LCA Project was put together by the Project Administration Committee and several bodies under it: the Inventory Study Group, the Impact Assessment Study Group, and the Database Study Group. Figure 2-2 provides an overview of the database, which includes inventory data that can be shared as background data, as well as an impact assessment list for use with the life-cycle impact assessment method based on endpoint modeling.[40]

The Inventory Study Group started out by defining inventory items and scope of data collection for 14 substances discharged into the environment (CO_2, CH_4, HFCs, PFCs, N_2O, SF_6, NOx, SOx, dust/particulate matter, BOD, COD, total phosphorus, total nitrogen, and suspended matter). It then proceeded to collect relevant data, as well as verify data quality and determine methods of data release and management. On the so-called venous side of the cycle, it assessed unit environmental load during waste disposal -- incineration, landfill operations, and so forth. It then compiled the findings as inventory data on each process and stored them as background data. The Inventory Study Group thereby collected 245 items of industry association data on some

[40] The life-cycle impact assessment method based on endpoint modeling is divided into fate analysis, characterization, damage assessment, impact aggregation, and consolidation. Fate analysis involves correlating inventory with density changes in an environmental medium; for example, CO_2 is analyzed as being related to density of greenhouse gases. Characterization involves correlating density of an environmentally harmful substance in an environmental medium with potential magnitude of impact in the impact category; for example, density of greenhouse gases is correlated with global warming. Damage assessment involves correlating impact category with damage magnitude at the category endpoint; thus global warming is correlated with heat/cold stress, infectious disease, malnutrition, disaster damage, timber production, agricultural production, land loss, energy consumption, and land ecosystems. Impact aggregation involves aggregating damage magnitudes at a wide range of category endpoints into four protected areas: human health, social assets, biodiversity, and primary production volume. Consolidation involves uniformly indexing the damage magnitudes for the four protected areas. A characterization factor list is used during the characterization process, a damage factor list is used during the damage assessment process, and a consolidation factor list is used during the process of uniform indexing.

200 products with respect to the 14 substances, prime among them CO_2, NOx, and SOx. It also collected 247 items of arterial survey data on resource extraction, overseas transport, etc., as well as 59 items of venous survey data on ordinary waste disposal processes. The rectangular boxes in the lower half of Fig. 2-2 represent the inventory of industry association data. On the left-hand side are listed resource and energy inputs; on the right-hand side, products and services.

The Impact Assessment Study Group considered (1) methods of quantitatively assessing the extent of damage that the protected entity would incur from an environmental load. It also discussed (2) the question of how much importance the assessor should attach to each protected area exposed to environmental impact. As a result 11 impact categories were defined (urban air pollution, harmful chemical substances, ozone layer destruction, global warming, ecotoxicity, acidification, eutrophication, photochemical oxidants, land use, waste, and resource con sumption), along with 4 protected areas (human health, social assets, biodiversity, and primary production volume). Then a life-cycle impact assessment method based on endpoint modeling was proposed; this is capable of assessing impact at each step from characterization to uniform indexing, as will be described below. As indicated in Fig. 2-2, three types of list have been proposed as part of this life-cycle impact assessment method: a characterization factor list, a protected-area damage-magnitude list, and a consolidation list. These are for use during the characterization, damage assessment, and uniform indexing processes.

The Database Study Group developed software for inputting collected data. It also developed an LCA database system. It thereby laid the groundwork for collection and release of industry association data and survey data. This database was actually made available for public access on a test basis between August 2003 - February 2004. A total of 1,354 users registered for this pilot program, most of them members of the 54 industry associations. During the seven-month period the database received some 8,100 logins, and there were roughly 5,100 downloads of inventory data. The site thus proved busy indeed.

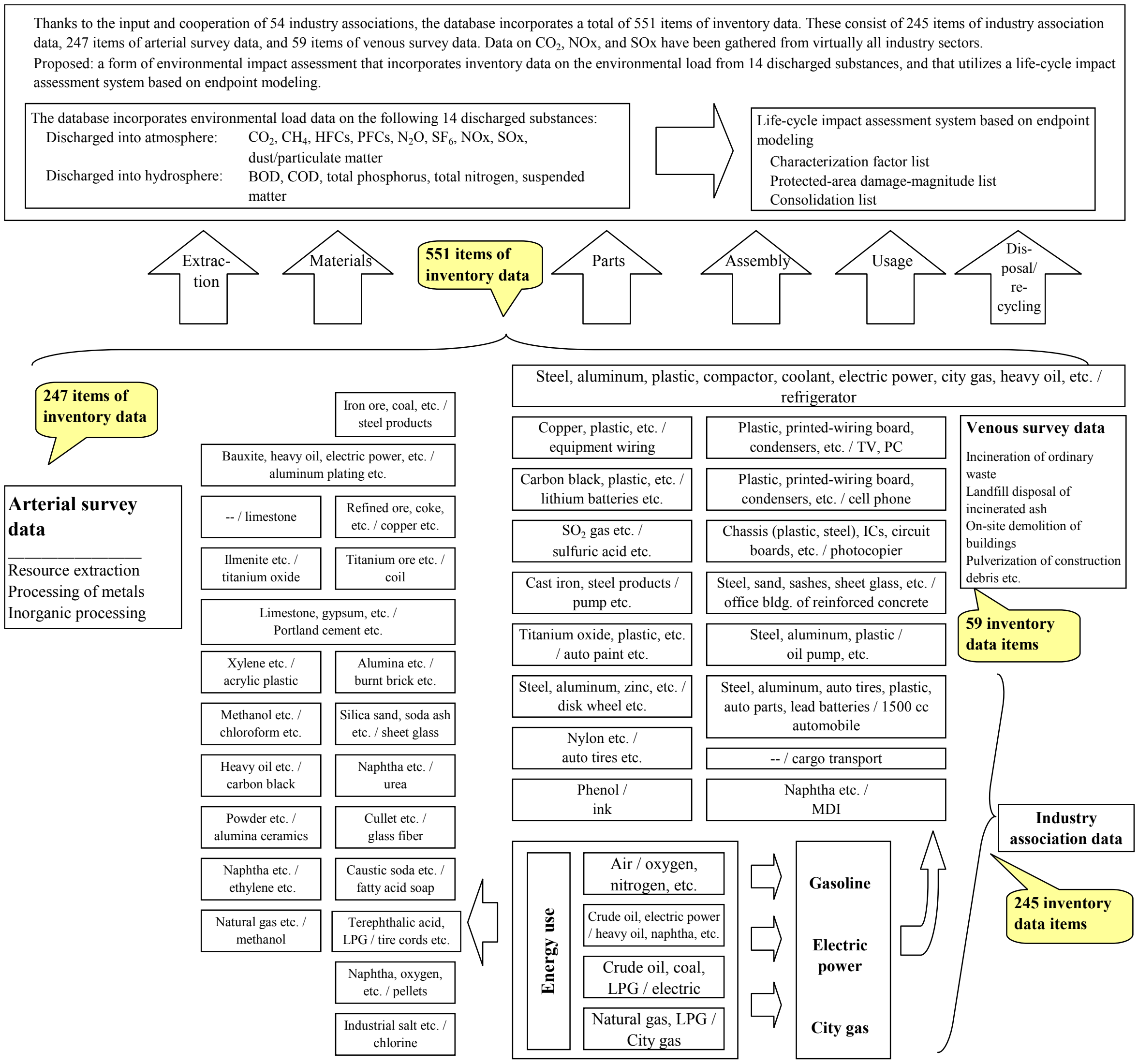


Figure 2-2. Overview of the LCA Project Database

Notes:
1. The left-hand side of each item of industry association data represents resource and energy inputs; the right-hand side represents products and services.
2. Inventory data relating to the same energy inputs or products, but at different stages, are counted separately.
3. Life-cycle impact assessment based on endpoint modeling is a method of quantitatively assessing environmental impact in individual categories, such as global warming and resource consumption, based on inventory data.

Sources: Same as Table 2-4.

III Challenges to Overcome in Promoting LCA Use

3-1. Problems with the LCA Database

Phase I of the LCA Project produced one of the world's largest LCA databases, a significant achievement. But at the same time a wide array of problems have emerged.

Table 3-1 gives a brief rundown of problems with the LCA database. On the vertical axis, problems are classified into two categories -- data collection and data use -- depending on the stage at which they occur. On the horizontal axis, specific examples of the chief problems are given; the nature of each is identified, along with the constraints it imposes. Under "Nature of problem," the problem is classified as either transitional or intrinsic. "Resulting constraints" are categorized into three types: data accuracy, increased difficulty of use, and restrictions on disclosure.

A frequently cited problem in the area of data collection is that of boundaries between adjacent data. The data boundary marks the limits within which specific LCA data are collected. The unit work processes included within the scope of an LCA are specified in accordance with its particular objectives; in the case of processes that are not that significant, upstream data may be omitted. Therefore the range of data crucial to assessing one product may differ from that crucial to assessing another, even if the component in question is the same. Strictly speaking, then, data should be collected in accordance with the particular objective. Phase I of the LCA Project had the goal of constructing a public database that could be used by anyone for diverse products and services. Therefore, rather

Table 3-1. Problems That Have Emerged with the LCA Database compilation

Stage at which occurs	Chief problems	Nature of problem		Resulting constraints		
		Transitional	Intrinsic	Data accuracy	Increased difficulty of use	Restrictions on disclosure
Data collection	Boundaries between adjacent data are often not adjusted; therefore it takes considerable practice to use the database properly.	○	○	○	○	
	Because multiple products are manufactured simultaneously, allocating energy use and so forth can be difficult (case-by-case allocation etc.).		○	○	○	
	Concerns that corporate secrets (costs and manufacturing know-how) could leak out limit ability to collect data and verify their accuracy.		○	○		○
	Differences between companies in setting of boundaries (e.g., distinction between internally manufactured and outsourced parts) and in manufacturing techniques can cause considerable discrepancies in the data. (Often figures vary by several times, or only incomplete data can be collected.)		○	○	○	
	It is difficult to obtain external data or data from abroad -- e.g., from suppliers of materials and parts.		○	○	○	
	There is a shortage of data on intermediate products and components, e.g., data on general-purpose electronic components and devices used in a relatively large number of products.	○			○	
Use	It is difficult to process data to match variations in product size.		○		○	
	Constant updating is required in the case of cell phones and the like, which quickly become outdated.		○		○	

Sources: Compiled by DBJ from materials from the Seminar on LCA Database Application organized by the Japan Environmental Management Association for Industry.

than being gathered with a specific product in mind, the data collected pertained only indirectly to specific products (i.e., it is background data), and the data were aggregated with the boundaries as set by the respective industry associations in accordance with their own criteria. In consequence, if one simply uses the data as recorded in the database, some processes may end up being duplicated, while others get omitted. Nonetheless, the information appears sufficiently accurate to be usable as background data, and to that extent there is no problem with using it. As is always the case when implementing an LCA, it is necessary to have a good understanding of the different types of data and realize their nature and limitations. The data boundary problem, it can be argued, is a transitional one, which can be expected to fade away gradually as the database is upgraded. On the other hand, setting appropriate boundaries can be difficult due to circumstances peculiar to specific materials and products, and in that sense the problem is more intrinsic. Companies all tend to differ on how they define the scope of different processes, and it is often necessary to expand or contract data boundaries in accordance with the purpose for which the data are being used.

A truly intrinsic problem is that of allocation. Matters would be perfectly straightforward if each factory only manufactured a single product. But the fact is that factories manufacture all kinds of things at the same time. In many cases, then, gauging input and environmental load for each product requires performing an allocation based on some criterion or another, such as weight or production value.

Another obstacle is corporate secrecy. In some industries there are concerns that disclosing actual amount of energy used might betray how a product is manufactured or reveal the costs involved. Similarly, in cases where, say, composition of a certain material is a corporate secret, disclosing LCA data could result in key know-how leaking out. The upshot is that in certain cases only data of questionable accuracy can be collected, or disclosure of data is limited.

One of the primary achievements of Phase I of the LCA Project, made possible in part by the guiding role played by the government in the process of data accumulation, was the collection of large amounts of broad-ranging data on materials and energy. But problems remain. There is a dearth of data on intermediate products, such as electronic components and devices, which have a wide range of applications; this is to an extent because collection of data has yet to make much headway among manufacturers of materials and components. The lack of data on general-purpose products like these is described as an urgent issue. But it is a transitional problem, and sooner or later definite progress should be made in rectifying it.

When it comes to actually using data, there is another problem. Data may only be available on products and components of a certain size, and if you are looking for data on, say, a component of a different size or with different specs, it can be difficult to process existing data to match your requirements. Then there are items such as cell phones and electronic devices that quickly become outdated: by the time they are entered in the database such that you can access information on them, they are already old and have largely gone out of use. Manufacturing techniques may also change; this again necessitates constantly updating the data.

The relative difficulty of compiling and releasing LCA data varies greatly from product to product. Releasing LCA data is easier for some items than for others, as Table 3-2 shows. This table classifies products according to two criteria: the value of the LCA information itself, and the relative technical difficulty of collecting LCA data. Collection of data progresses rapidly in the case of items for which LCA information is of high value -- for example, things like photocopier toner and disposable cameras, where the availability of recycling tends to become an issue and can be a way to differentiate your product. Or say it is clear in what direction regulation is heading, such as in Europe, where use of particular harmful substances is to be banned at some point in the future. A manufacturer may in that case choose to make a preemptive move by proclaiming on, for example, a Type III ecolabel that its products contain no such substances. Disclosing LCA data is also of greater value if users adequately understand such data and can make effective use of them; products typically subject to green purchasing programs of the type run by public bodies constitute a case in point.

On the technical front, collection of LCA data tends to proceed more smoothly in the case of products that are of simple design, or products whose technique of manufacture does not vary greatly from manufacturer to manufacturer, for then it is easy to reach agreement on data collection standards. It costs a fair amount to collect LCA data, obtain third-party certification, and release the relevant information, and the product or manufacturer in question needs to be able to afford those costs.

Figure 3-1 presents a schematized diagram, based on the foregoing analysis, showing state of progress in compiling LCA data. The vertical axis indicates the value of the LCA information: the value increases the higher up one goes. The horizontal axis indicates level of technical difficulty: the difficulty increases the further to the right one goes. Technical difficulty translates directly into cost of data collection; it may also be thought of as the quality of data. A variety of companies are today running in-house LCA programs and collecting relevant data, though their

Table 3-2. Relative Difficulty of Compiling and Releasing LCA Data

Category		An item is easy to release LCA data on when…	An item is difficult to release LCA data on when…
Value of LCA information	Differentiation of products	Disclosing LCA data helps differentiate it (e.g., photocopier toner or a disposable camera, where recycling is an issue), and it is difficult to differentiate otherwise.	Other factors are more important than LCA data (e.g., materials, parts, etc.).
	European environmental regulations etc.	Availability of LCA data makes it easier to ensure compliance.	LCA data are irrelevant. It contains no harmful substances.
	Users's capacity	It is designed for professional buyers like companies and government agencies, which can interpret the LCA data. Green purchasing programs etc.	It is designed for consumers, who do not understand LCA data anyway.
Level of technical difficulty	Product design and structure	The design is simple, making it easy to collect LCA data.	The design is complex, making it difficult to collect LCA data
	Method of manufacture and setting of boundaries	There is little difference between companies.	There is considerable difference between companies.
	Corporate secrecy and competitiveness	Neither is affected by disclosure of LCA data.	Disclosure of LCA data directly affects corporate secrecy and competitiveness.
	Profitability of the product	It is highly profitable.	It is not that profitable.
	Cycle of new product introduction	The cycle is long.	The cycle is short.
	Labour and Cost bearing capacity	The manufacturer can afford LCA implementation cost.	The manufacturer can ill afford the cost.

Sources: Compiled by DBJ.

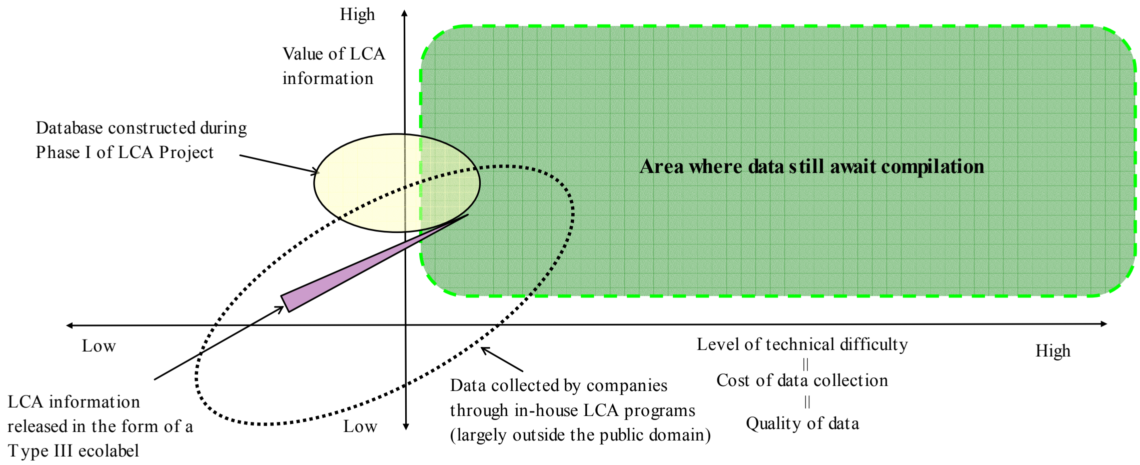


Figure 3-1. State of Progress in Compiling LCA Data

Sources: Compiled by DBJ.

absolute number is still not that great. But most such internal data are not released to the public domain. The only corporate data released in the form of a Type III ecolabel are those that are of the level of quality required to obtain the necessary certification and that are worth spending extra money on to release in that form. In many cases, it would seem, the data currently available in the form of Type III ecolabels consist of information that is relatively easy to collect. In the diagram, therefore, Type III ecolabels occupy a broad diagonal swathe to the lower left. Then there are the data collected during Phase I of the LCA Project, which is noteworthy for having collected a broad array of previously unavailable data on materials and such under the guidance of various industrial associations backed by the government. Although considerable progress has been made in putting together a database, there are still many fields where data has yet to be properly compiled. Constant updating is also needed. It costs a considerable amount to collect LCA data of a high degree of accuracy and usability, no matter how valuable for society as a whole those data may be. It may also happen that, depending on the data collected, manufacturers may not be happy with the results. Things that individual manufacturers do not wish to reveal may become public knowledge, though for society as a whole LCA data are of tremendous value. Thus it is advisable for society as a whole to collect such data as a form of infrastructure. After all, without public intervention, there is the danger that only data that are to the advantage of certain manufacturers will make it into the database.

3-2. Major Problems with LCA and Solutions to Them

Problems are not confined just to the database. There is a host of problems with corporate LCA use overall. Fig. 3-4 lists the issues that came to light in a series of interviews with a wide range of firms in many different industries.

On the horizontal axis are listed examples of problems along with sample remedial measures. Along the vertical axis these are classified into three: data collection, method of data use, and external environment.

Problems with data collection are broadly divided into three: comparability, outside data, and time and cost. In collecting LCA data for business use, a key question is how to collect comparable data of high quality across a broad front -- encompassing subcontractors and overseas firms as well -- in minimal time and at minimal cost. The problems in this area, while often identical to those that crop up with the database, in many cases directly relate to day-to-day business operations, perhaps because implementation of individual LCA programs is a more practical matter. These problems include collection of data from outside, including subcontractors, collection of overseas data, and the time and cost constraints imposed by competition to develop new products. The most important single remedial measure is raising level of knowledge among materials and parts manufacturers and among medium and small businesses. Where corporate secrets are involved, it would be worth considering the possibility of having a neutral, impartial agency intervene between medium and small suppliers and manufacturers.

Problems relating to using data are no less diverse than those relating to collecting them. Here problems with methods of use are divided into three: techniques of use, consumer response, and Type III ecolabels. Some problems in this area are of a technical nature, such as shortages of skilled personnel, errors in LCA results, the difficulty of channeling feedback into the design process, and so forth. There are other issues as well, such as inadequate understanding on the part of the consumers to whom LCA data is made available, as well as the question of who enjoys the resulting benefits. Problems exist too with Type III ecolabels, which are now coming into widespread use, in the areas of costs and of interpreting and assessing data. Type III ecolabels disclose large volumes of extremely detailed data, but it is difficult for the average consumer to understand and assess that information in its entirety. As for remedial measures, several come to mind. These include developing human resources by organizing public training programs and offering subsidies, harnessing data for the purpose of green procurement programs run by public bodies, and enabling manufacturers to reap some of the benefits of their LCA activities

Table 3-3. Specific Problems with LCA That Came to Light in Interviews

Category		Example of problem	Sample remedial measures
Data collection	Comparability	Differences in methods of manufacture and setting of boundaries are so great that it is difficult to standardize conditions for collection of data. Imposing rough uniformity could end up obscuring firms' individual efforts.	Refine methods of collecting and verifying data. Accumulate experience. Restrict use.
		Collecting comparable data requires disclosure of all that happens on the production floor, which would mean revealing everything from production efficiency to how well the company is run. What happens on the production floor is a corporate secret: it cannot be disclosed.	Refine methods of collecting and verifying data. Accumulate experience. Restrict use. Make use of a neutral agency.
	Outside data	Producers of materials and parts have no incentive to participate, since the manufacturer of the final product will end up getting all the credit for their hard work.	Refine methods of disclosing information. Develop and expand public databases.
		In data collected from outside, products are only roughly classified (merely as typical products).	Accumulate experience. Systematize.
		Outside information accounts for the lion's share of data, yet collecting data from parts manufacturers etc. is difficult unless there are financial ties.	Raise level of LCA knowledge among materials and parts manufacturers and medium and small businesses. Systematize.
		LCA data directly affect competitiveness and corporate secrecy.	Make use of a neutral agency. Use data from input-output tables.
		It is difficult to collect data from abroad of the same quality as domestic data.	Establish an international data collection regime. Provide assistance to developing countries. Systematize.
		When a company tries to tap outside databases, they tend not to have much data. Even when they do, data may vary by several times from database to database, or the information may be fairly old.	Develop and expand a public database devoted primarily to basic materials and components. Accumulate experience.
	Time/cost	Collecting data takes time (it can occupy several people for anywhere from a few days to half a year). In product development, time is of the essence. There is little inclination to spend time on extra tasks.	Accumulate experience. Systematize.
		Costs are an obstacle -- and that holds for parts manufacturers etc. as well. While not huge, they cannot be ignored.	Accumulate experience. Systematize.
Methods of data use	Techniques of use	Companies have few employees with the ability to understand and make effective use of LCAs. There is little written on the subject. Consultants are expensive.	Accumulate experience. Public training programs and subsidies, etc.
		Acquiring LCA data takes time, so they cannot be used at the product design stage. At the design stage you have to resign yourself to using more or less provisional figures rather than actual measurements.	Compile data and enhance accuracy. Systematize. Develop simplified LCA techniques.
		Identifying a bottleneck is not the same thing as finding a remedy. Determining the difference in size of environmental load between components does not necessarily translate into an instant remedy, since some components cannot be replaced.	Accumulate experience. Develop systems.
		Diverse forms of LCA data cannot easily be managed on an integrated basis. Although progress is being made in developing methods of assessing environmental impact, they are still only of limited use.	New research and development. Accumulate experience. Refine and restrict use. Get users to improve their knowledge.
		Processing data takes time, but that is unacceptable from the viewpoint of product development, where time is of the essence.	Accumulate experience. Systematize. Develop simplified LCA techniques.
		There is no adequate mechanism for third-party evaluations. Every company uses data as it likes.	Develop rules of use. Conduct proper monitoring.
		LCA results end up serving purely as background information, since margins of error are so great.	Enhance data accuracy. Refine use.
	Consumer response	Consumers do not properly understand the information and fail to use it as a decision-making tool when purchasing an item. Consumer needs are unclear.	Harness data for the purpose of green procurement. Get users to improve their knowledge. Make use of Type I and II ecolabels. Refine methods of information disclosure, e.g., rate the data.
		Even if a company reduces a product's environmental load through an LCA program, it fails to reap any benefit. There is no clear means of allocation with the consumer.	Accumulate experience. Allocate benefits in a manner that reflects the balance of risks and returns from improvements at the LCA level and also takes account of the impact of environmental regulations.
	Type III ecolabels	Even if data are tabulated as the standards dictate, they may still not be comparable, since differences may remain in how boundaries are set between, say, internally manufactured and outsourced parts.	Revise standards. Accumulate experience. Refine and restrict use. Standardized basic EcoLeaf units.
		The process of verifying and approving a Type III ecolabel takes over a month. That is a big problem for product development, where every second counts.	Expenditures and required time for second and subsequent LCAs are dramatically slashed. System certification for EcoLeaf.
		Initial acquisition of Type III ecolabel certification requires that industry representatives get together to set standards for the product in question. That can take up to six months because so many different processes are involved.	Expenditures and required time for second and subsequent LCAs are dramatically slashed. Adopt the EPD pre-certification system.
		It costs several million yen in outside fees to obtain certification, and the internal manpower costs are also considerable. Yet only a limited number of products can carry the label. (This applies to cases where costs are relatively high.)	Expenditures and required time for second and subsequent LCAs are dramatically slashed. Conduct LCAs and disclose information at public expense.
		It costs several tens of millions of yen to obtain certification, but there are no tangible returns on the investment. (This applies to cases where costs are very steep.)	Expenditures and required time for second and subsequent LCAs are dramatically slashed. Promote green procurement, get users to improve their knowledge.
		The Type III ecolabel is merely a vehicle for disclosing objective data: assessing the relative merits of the product in question is difficult. It does not do a good job of highlighting areas where fresh improvements have been made. Nor can it be used as a motivator for product development in house.	Harness data for the purpose of green procurement. Get users to improve their knowledge. Make use of Type I and II ecolabels. Refine methods of information disclosure, e.g., rate the data.
External environment	Government policy	The Kyoto Protocol lacks an LCA perspective. Thus efforts to reduce emissions on an LCA basis are not given the credit they deserve.	Incorporate an LCA approach into domestic policy. Adopt an LCA perspective in international negotiations, one that builds on successes at home.
		The Recycling Promotion Law and Green Purchasing Law are only concerned with the usage phase: they lack an LCA perspective. Other policy measures are similarly inadequate or inconsistent.	Make systemic improvements, e.g., choose items with favorable LCA data when purchasing. Accumulate experience.
		Response to, say, European environmental regulations varies from company to company. Therefore medium and small suppliers tend to end up being at the mercy of whatever the big companies that are their customers decide to do.	Make systemic improvements to ensure that leading companies take a standardized response. Also discuss the possibility of standardizing environmental regulations at some point, as these could turn into a trade barrier.
	Miscellaneous	Demand for products that offer greater safety and comfort is growing, increasing the load on the environment.	Further boost LCA management efficiency.
		An LCA system for assessing a company's operations per se would be welcome, but it is difficult to define boundaries and so forth.	Accumulate experience.

Sources: Compiled by DBJ based on interviews.

in a manner that reflects the balance of risks and returns from improvements at the LCA level. With respect to Type III ecolabels, methods of disclosing information could be refined: LCA information might be disclosed at public expense, for example, or products and services could be rated/interpreted by third-party rating agency regarding LCA environmental load. Furthermore, the important thing for LCA data providing companies is to actually carry out an LCA. Perform an LCA once, they say, and from the next time on there will not be so much labor and cost involved. Thus the key question is how to induce companies to execute that first LCA. One effective approach would be to provide some form of public funding to help cover the cost of the first LCA performed by a manufacturer of a key material or component, particularly if it is a medium-sized or smaller firm.

Problems relating to external environment are classified into two: government policy and miscellaneous. One problem is the lack of an LCA perspective in the Kyoto Protocol and related domestic legislation, as well as in the Green Purchasing Law. Then there is the problem of the overall business climate: in the case of so many products and services, demand for greater safety and comfort is constantly rising, and that ends up increasing the load on the environment. A move is afoot in green purchasing to get legal controls to incorporate an LCA perspective -- a move that one hopes will make further headway.

Table 3-4 analyzes the sample remedial measures identified in Table 3-3, classifying them according to whether the private sector can handle them or public intervention should be considered.

Even left to its own devices, the private sector can be expected to achieve reasonable progress in, for example, accumulating experience and streamlining the process of setting standards for individual products. But on its own, it is not likely to make much headway in implementing LCAs and disclosing information with respect to basic components/devices and the like, or again in developing human resources. After all, while such steps are of great value in developing public assets, they do not offer very much of an advantage to the manufacturers that must bear the costs of data collection etc. These steps relate essentially to the development of public infrastructure, and government intervention should thus be considered. In order to eliminate concerns about revealing corporate secrets or worries that disclosing data could lead customers to haggle for lower prices from suppliers, it would be worth considering the possibility of intervention by a third-party data collection agency that is impartial, neutral, and able to keep information confidential. Then there is the need to raise level of knowledge among materials and parts suppliers and medium and small businesses. The absolutely crucial thing here is to get companies to implement their first LCA. An effective way of accomplishing that would be to lower the initial hurdle by providing some form of public funding to help cover the cost of the first LCA. For example, assistance could be provided with releasing the LCA results.

As for data use, the private sector can on its own be expected to make fair progress in many areas, such as enhancing comparability, cutting LCA implementation costs, and making use of data to design more eco-friendly products. But there are some things that cannot very well be accomplished without public intervention: for example, enabling manufacturers to reap the benefits of their LCA activities in a manner that reflects the balance of risks and returns from improvements at the LCA level. Also worth considering is public intervention where a neutral stance is required, such as when rating and interpreting LCA data.

Another area where public intervention should be considered is the imposition of rules through legal regulations, since here neutrality and enforceability are required, and such rules constitute a form of public infrastructure in their own right.

LCA implementation is important, but the question of whether to impose a legal requirement to perform LCAs is one that should be approached with caution. After all, carrying out an LCA costs a fair amount of money, yet the benefits that derive from pursuing better performance at the LCA level accrue to society as a whole: they are not enjoyed exclusively by the individual company that performed the LCA. Rashly making LCAs obligatory could well result in honest companies losing out while more devious

Table 3-4. Analysis of Remedial Measures Designed to Promote LCA Use

Category	Remedial measure	Can be handled by private sector	Why private-sector action difficult	Consider public intervention
Data collection	Accumulate experience; new research and development.	○	Public infrastructure	△
	Streamline the process of setting standards for individual products (pre-certification etc.).	○	Neutrality	△
	Put in place a data gathering system.	△	Public infrastructure	○
	Set up a third-party data collection agency that is impartial, neutral, and able to keep information confidential.	△	Neutrality	○
	Develop and expand databases.	△	Public infrastructure	○
	Implement LCAs and disclose information with respect to basic components etc. at public expense.		Public infrastructure	○
	Establish an international data collection regime.		Public infrastructure	○
	Develop LCA expertise (expand education and training programs for materials and parts suppliers).		Public infrastructure	○
	Raise level of LCA knowledge among materials and parts suppliers and medium and small businesses.		Public infrastructure	○
	Improve methods of information disclosure (such that materials and parts suppliers benefit as well).		Neutrality	○
	Providing subsidies for the first LCA would be an effective move, since the expenditures and time required for second and subsequent LCAs would then be greatly reduced. This would also allow companies to accumulate experience and raise quality, so that understanding of LCA would advance dramatically.		Learning by doing	○
Methods of use	Enhance comparability (standardize basic units used).	○		
	Cut costs (system certification etc.).	○		
	Develop technologies for making use of LCA data in designing more eco-friendly products.	○		
	Get consumers and users to improve their knowledge (education and training).	△	Public infrastructure	○
	Harness data for the purpose of green procurement.	△	Ability to bear cost	○
	Take advantage of other types of ecolabels.	○	Neutrality	△
	Refine methods of information disclosure, e.g., rate the data.	△	Neutrality	△
	Enable manufacturers to reap the benefits of their LCA activities in a manner that reflects the balance of risks and returns from improvements at the LCA level.		Neutrality, enforceability	○
Legal regulations	Establish rules of use, put in place a monitoring regime.		Neutrality, enforceability	○
	Improve the legislative framework by incorporating an LCA perspective.		Public infrastructure	○
	Standardize environmental regulations and requirements.		Public infrastructure	○

Sources: Compiled by DBJ based on interviews.

companies gain the upper hand. It may also happen that the environmental load seems apparently greater when a company scrupulously measures data that it has cost money to gather. Conversely, companies might leave out information on processes that impose a heavy environmental load and only release data that is favorable to them, so that superficially the data will look good. But proper outside monitoring would cost the government a fortune. An LCA regime that serves the needs of society is not going to take root unless it rewards those who play by the rules. Positive incentives are to be preferred as the way to guide industry in the right direction: that means giving carrots to pioneering companies that implement LCAs and put the results to good use.

IV Utilizing LCA to Achieve Total Optimization of Global Warming Measures

4-1. Concrete Steps Taken by the Private Sector to Overcome Obstacles to LCA Use

Companies in the private sector are taking a host of concrete steps to overcome problems with LCA. While it is impossible to provide an overview of them all, Fig. 4-1 sums up some of the more prominent among them based on interviews, dividing them into two categories: data collection and LCA use.

In the area of data collection, descriptions are given of two types of approaches: a program undertaken in the medium and small business sector, and remedial steps involving system development. Osaka-based Nichigoh Communication Electric Wire Co., Ltd., not by any means a large firm, is working to obtain EPD certification in an attempt to differentiate itself from the competition on the environmental front. In the course of collecting LCA data it identified bottlenecks in its manufacturing processes, remedying which generated direct cost-saving benefits in the form of cost reductions and the like. This example demonstrates that even not very big companies can pursue fairly sophisticated strategies if they set their minds to it. Other medium and small businesses will, one hopes, follow suit. Fujitsu's Virtual Product Simulator (VPS) is a system for computing the data on environmental load required to perform an LCA. It does so by collating information on a product's design with databases on environmental load etc. The Honda LCA System is a system that uses intranets as a way of efficiently collecting LCA data on overall corporate operations in partnership with suppliers and sales firms. Particularly noteworthy is the way that suppliers and other parties that furnish and input data are given incentives to cooperate in the form of the benefits they gain in such fields as waste management.

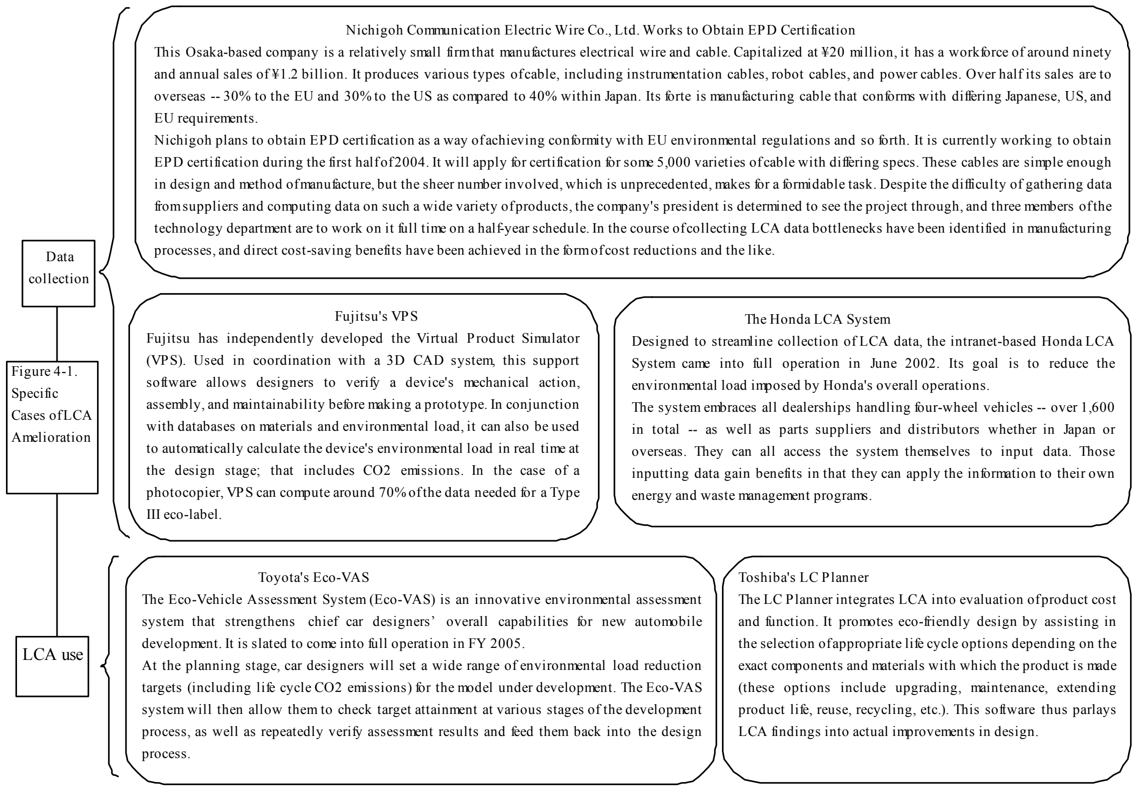


Figure 4-1

Source: Compiled by DBJ based on interviews.

In the area of LCA use, there is a trend toward seeking solutions through system development. Toyota's Eco-Vehicle Assessment System (Eco-VAS) is intended to facilitate development of cars that impose a low environmental load in LCA terms by enabling car designers to perform LCA data estimates at various stages of the design process. This system deserves particular note as a pioneering effort in the field of car building, where several tens of thousands of components are involved. Toshiba's LC Planner is intended to promote eco-friendly design by making available LCA data and assisting in the selection of appropriate remedial strategies.

Thus wide-ranging action is being pursued even in areas where the large number of components used greatly complicates the task of gathering and utilizing LCA data. Moreover, some medium and smaller firms are taking pioneering steps as well.

The FY 2003 follow-up report on the Keidanren Voluntary Action Plan describes the main cases of particular industries contributing to emissions reductions in other industries or sectors.

The automobile industry expects to be five years early in attaining the fuel efficiency targets set for FY 2010 under the Energy Conservation Law Top Runner standards. It makes sense to achieve emissions reductions as quickly as possible regardless of the deadline prescribed in the Kyoto Protocol, since the problem of global warming boils down to a question of greenhouse gas stocks. The volume of emissions in 2008-2012, the period set in the Kyoto Protocol, will be affected too: achieving improvements in fuel efficiency five years ahead of schedule will make a huge difference in the level of progress as of FY 2010, since by then the automobile fleet will have largely been replaced. Assuming sales of roughly four million vehicles a year, in five years twenty million vehicles, or around half the passenger car fleet, will be replaced by cars compatible with Top Runner standards. A decrease in gasoline consumption of 200 liters per vehicle per year[41] will save a total of four million kiloliters annually, which translates into approximately nine million tons of CO_2. That represents a reduction in emissions equivalent to over 60% of the 14 million tons of CO_2 generated overall in the manufacture of automobiles, automobile components, and automobile bodies.[42]

The steel industry now manufactures light-weight, high-efficiency, long-lasting steel plate for use in vehicles, ships, and trains. It is estimated that, as of FY 2000, the use of such plate cut CO_2 emissions by 5.68 million tons due to, e.g., improvements in fuel consumption from reductions in vehicle weight. Producing this steel plate increases CO_2 emissions at the manufacturing stage by 170,000 tons, but the subsequent reductions more than make up for that amount.

In the oil refining sector, desulfurization[43] of gasoline and diesel oil promises to alleviate air pollution, but at the refining stage it actually increases CO_2 emissions by some two million tons a year. Nonetheless, the potential gains are considerable when viewed overall. Desulfurization per se reduces the load on the environment, and if there is an increase in ownership of vehicles equipped with high-efficiency direct-injection engines, which are best suited to desulfurized fuel, it is estimated that the resulting improvements in fuel efficiency could cut CO_2 emissions by some two million tons.

The automobile parts industry is implementing such steps as restricting employees from commuting by private vehicle. It is significant that companies are even taking measures like these that could well reduce sales of their own products.

The transportation sector is not the only beneficiary; so too is the commercial and residential sector. Various appliances manufactured by the electronic and electrical industry, such as refrigerators, televisions, air conditioners, and personal computers, are subject to the Energy Conservation Law Top Runner standards. Meeting these targets will shave an estimated 30 mil lion tons off CO_2 emissions as of FY 2010. A

[41] On the assumption of a roughly 20% improvement over actual fuel efficiency for FY 2001, when average fuel efficiency was 8.65 km per liter for a car traveling 10,000 km a year (handout distributed at Meeting 13 of the Global Environment Council of the Central Environment Council, Feb. 25, 2004).

[42] Actual figure for FY 2002.

[43] Reduction of sulfur content to less than 10 ppm.

Table 4-1. Examples of LCA-related Global Warming Measures in Industry

Beneficiary	Industry taking the action	Main cases of contributions to emissions reductions in other industries or sectors as described in the FY 2003 follow-up report on the Keidanren Voluntary Action Plan
Transportation sector	Automobiles	Will achieve Energy Conservation Law Top Runner targets ahead of schedule. Approx. 70% of domestically sold vehicles in FY 2002 met the FY 2010 fuel efficiency target (23% improvement over FY 1995). By FY 2005 the number will be over 90%. Attaining the targets five years early will have a dramatic cumulative effect.
		Participates actively in ITS (Intelligent Transport Systems).
	Steel	Cut CO_2 emissions by 5.68 million tons as of FY 2000 by supplying light-weight, high-efficiency, long-lasting products (high-strength steel plate for vehicles, high tension steel plate for ships, stainless steel plate for trains). Producing such plate increases CO_2 emissions at the manufacturing stage by an estimated 170,000 tons.
	Oil refining	Desulfurization of gasoline and diesel oil boosts fuel efficiency of vehicles (by approx. 5% for gas-powered vehicles and 4% for diesel-powered vehicles; that may reduce CO_2 emissions by as much as 2 million tons a year, depending on conditions). CO_2 emissions at the refining stage increase by an estimated 2 million tons a year (1.3 million for gasoline, 0.7 million for diesel).
		Aims to cut transport fuel consumption by 9% over FY 1990 by, e.g., sharing oil depots and swapping products. Achieved a 7.9% reduction as of FY 2002.
	City gas	A million natural gas vehicles on the road would cut CO_2 emissions by 470,000 tons a year.
	Distribution, papermaking, nonferrous metals	Is streamlining distribution by, e.g., outsourcing or pooling deliveries, cutting number of delivery vehicles, using larger trucks, switching to rail or ship, and forming business tie-ups.
	Papermaking	Improves final unit CO_2 emissions by 35% thanks to gains in transport efficiency from compacting tissue paper.
	Automobile parts	Restricts commuting by private vehicle.
Commercial/residential sector	Electronic and electrical	Reduction in CO_2 emissions from appliances subject to Energy Conservation Law Top Runner standards (refrigerators, TVs, air conditioners, PCs, etc.): approx. 30.4 million tons as of FY 2010.
		Improvements in office air conditioning and lighting, installation of cogeneration, ice thermal storage, and solar generating systems: 1.82 million ton reduction in CO_2 emissions in FY 2002.
		Semiconductors and liquid crystal displays help save energy on many fronts. LCDs cut $LCCO_2$ emissions by over 40% compared to CRTs.
	City gas	By enhancing efficiency of gas-powered equipment such as stoves and water heaters and promoting the spread of energy-saving devices such as cogeneration systems, the goal for FY 2010 is to improve efficiency at the consumption stage by 13% compared to FY 1990. That would reduce annual CO_2 emissions by some 10 million tons. Estimated reductions of 4.8 million tons were achieved in FY 2002.
	Sheet glass	Is promoting use of double-glazed glass. Replacing windows in existing homes throughout Japan with low-e double-glazed glass (low-emissivity glass with a metallic coating on the inside) would cut CO_2 emissions by 17 million tons a year. It takes 10-20 years to recover the investment, the period being shorter the colder the climate (it takes more than 20 years if renovating an existing home).
	Electric power	Is developing high-efficiency water heaters and heat storage systems and promoting their use.
Other	Cement	Saves natural resources by using waste and byproducts from industry and ordinary homes as alternative fuel and raw material. In FY 2002 it used 27 million tons of such material. This alleviates the problem of the shortage of final disposal sites and reduces the environmental load from incineration or landfill disposal of waste. It is more efficient than other waste disposal methods.
	Steel	Supplies blast-furnace slag for cement. In FY 2002 blast-furnace cement accounted for approx. 20% of overall cement production. This reduces CO_2 emissions by 5.23 million tons a year.
		Reduced CO_2 emissions by an estimated 820,000 tons as of FY 2000 by supplying light-weight, high-efficiency, long-lasting products (heat-resistant steel tubing for boilers, electromagnetic steel sheets for transformers).
	Automobiles	Takes prompt action to switch the coolant used in car air conditioning from CFC 12 to HFC 134a.

Sources: Compiled by DBJ based on, e.g., documentation from the Joint Follow-up Subcommittee on the Keidanren Voluntary Action Plan (a joint subcommittee of the Industrial Structure Council and the Advisory Committee for Natural Resources and Energy).

substantial portion of those reductions will come from the use of semiconductors and liquid crystal displays, which however result in increased emissions at the manufacturing stage. In the city gas industry, estimated reductions of some 4.8 million tons in CO_2 emissions were achieved in FY 2002. These came from efficiency gains in such gas-powered equipment as stoves and water heaters, along with the spread of energy-saving devices such as cogeneration systems.

Other contributions to emissions reductions include that of the cement industry to waste disposal, and reduction of emissions from cement manufacture through the use of blast-furnace slag from the steel industry.

Thus even today some of the steps being taken by industry are greatly helping to reduce emissions in other sectors. Nevertheless, such efforts are still sporadic, and it is difficult to assess them accurately. Putting in place a regime for objectively evaluating results and providing systematic support should stimulate further progress on this front.

4-2. Advantages of and Caveats to Using LCA

LCA offers numerous advantages, as Table 4-2 shows. The first objective of implementing LCA that may be cited is determining overall environmental load and identifying key points for effectively and efficiently reducing it. Potential benefits from an LCA performed for this purpose include the design of eco-friendly products, and the effective, efficient reduction of the environmental load imposed by a company's overall operations. Encouraging such steps is a good way to efficiently harness the resources of private-sector companies, which have a considerably greater management capacity than do ordinary households, and thus alleviate the load on the environment in the interests of society as a whole. If, rather than being urged to take measures that are beneficial from an LCA standpoint, companies are simply required to make improvements at the production stage only or merely boost the energy efficiency of their products, the outcome may not be to the greater good of society. Companies may concentrate their limited resources on stages of the cycle where it is difficult to take effective action, with the result that they are unable to achieve quantitatively significant reductions. Or, by acting without considering overall impact, they may end up triggering an increase in emissions at some other stage of the cycle. Requiring companies to make improvements from an LCA perspective, rather than just focusing on a single stage of the cycle, will enable reduction of emissions to proceed efficiently and effectively, for this approach grants far greater flexibility to manufacturers in what strategies they can choose. The important thing is to properly motivate those actors who possess management ability and give them greater leeway to exercise it.

Table 4-2. Why Implement LCA

Objectives of LCA	Benefits of LCA
Determine overall environmental load, identify key points for effectively and efficiently reducing it.	Effective, efficient management of the environmental load imposed by a company's overall operations, e.g., design of eco-friendly products. Efficient harnessing of private-sector resources.
Provide information on environmental load (e.g., to green purchasing program administrators).	Way to differentiate one's product, encourage sustainable consumption.
Achieve conformity with EU environmental regulations etc.	Pre-emptive action. Compliance.
Fulfil corporate social responsibility.	Corporate image. Socially responsible investment.

Sources: Compiled by DBJ.

Another objective of LCA is to provide the information on environmental load required for such purposes as green purchasing. In the case of certain items, like copying machine toner cartridges and disposable cameras, disclosing LCA information is a way to distinguish oneself from the competition. Compiling LCA information is thus at the same time a means of encouraging sustainable consumption.[44]

[44] I.e., making consumption sustainable by getting consumers to choose wisely when buying products and reconsider how to make better use of them. Examples include consuming recyclable resources only in so far as they can actually be recycled, and imposing only so much of a load as the natural environment can handle. The United Nations Environment Programme (UNEP) is taking steps to support such efforts.

EU environmental regulations require that substances that impose an environmental load be properly managed from an LCA perspective. Also under discussion is a directive requiring that products be designed in a manner consistent with LCA thinking. For example, the RoHS directive restricts use of lead, mercury, hexavalent chromium, cadmium, and the like; companies that now use these substances in manufacturing electrical appliances and electronic devices sold in the EU market will be required to use alternatives in products shipped to market after July 1, 2006. Uncertainties remain about rules for complying with such directives; for companies choosing to take preemptive action, one possible strategy would be to get certified for a European Type III ecolabel declaring that the product in question contains none of the prohibited substances. Companies will feel more confident about purchasing and using materials and components for which suppliers have obtained such ecolabel certification.

The European Commission is also pursuing a policy known as IPP,[45] which demands taking the most effective action for minimizing the environmental load imposed by all products and services at all stages of the life cycle, from manufacture and usage through disposal. Exact details are still being ironed out -- a green paper was only released in February 2001 -- and specific steps have yet to be imposed as requirements or enshrined in law. Still, this development deserves attention as suggesting what the future holds. On the subject of IPP, a draft version of a directive on energy-using products (EUP)[46] was released in August 2003; this directive would establish a framework imposing requirements for minimum energy efficiency and eco-friendly design on energy-using products. Future developments in this area will be watched with interest.

In recent years stakeholders (consumers, local residents, employees, shareholders) have become increasingly vociferous about corporate social responsibility (CSR). Performing LCAs and managing the environmental load imposed by corporate operations overall is significant also from a CSR standpoint. It has more than merely the abstract virtue of burnishing one's corporate image; it also offers a host of more concrete advantages that are only now coming to be recognized. It attracts socially responsible investment (SRI),[47] for example, and has a favorable impact on recruiting.

LCA is of great import in that it offers these advantages. But there are also certain caveats to using LCA. Table 4-3 lists the primary of these.

Table 4-3. Caveats to Using LCA

Caveat		Solution
Discrepancy between who bears cost and who reaps benefits	Benefits of LCA accrue to society as a whole, yet private-sector firms can only partially enjoy them.	Government should ensure that gains are fairly channeled back to cost-bearers.
Uncertainty of LCA data	LCA figures are somewhat uncertain and cannot be treated as equivalent to actual reductions in CO_2 emissions. The numbers must be handled on the assumption that they may vary considerably, as they often differ by a factor of ten.	Set appropriate discount rates.
Time lag and risk involved in realization of benefits at the LCA level	There is a risk as to the extent to which benefits at the LCA level, such as reduced emissions at the usage stage, will actually be achieved. Conversely, achieving such benefits in the future may entail incurring direct costs now (e.g., hybrid cars, LCDs, etc).	Set appropriate discount rates.

Sources: Compiled by DBJ.

The first caveat that may be cited is the discrepancy between who bears the cost and who reaps the benefits. The benefits derived from LCA -- alleviating the environmental load imposed by extraction of materials, saving energy

45 See Note 26.

46 "Proposal for a Directive of the European Parliament and of the Council on establishing a framework for the setting of Eco-design requirements for Energy-Using Products and amending Council Directive 92/42/WWC," Brussels, 01.08.2003, COM (2003) 453 final, 2003/0172 (COD).

47 I.e., when investing, taking into consideration not just traditional investment criteria, such as financial situation, but also whether or not the company is fulfilling its social responsibilities on the societal, ecological, and ethical fronts. There has long been an aversion to investing in companies in the tobacco, gambling, and arms sectors, but more recently companies also face growing demand to furnish information on the degree to which they address environmental concerns and their level of legal compliance throughout their operations.

at the production and consumption stages, boosting recycling rates -- extend to many quarters of society. However, manufacturers and other private-sector firms can only partially enjoy those benefits, since most of the gains made in alleviating environmental load are not reflected in product prices. For manufacturers the advantages are typically minuscule: lower manufacturing costs, for example. Manufacturing costs and emissions at the manufacturing stage may actually rise. Therefore the government, being in a position to manage the benefits to the whole of society, including other sectors, needs to intervene to ensure that the gains are fairly channeled back to those who bear the costs.

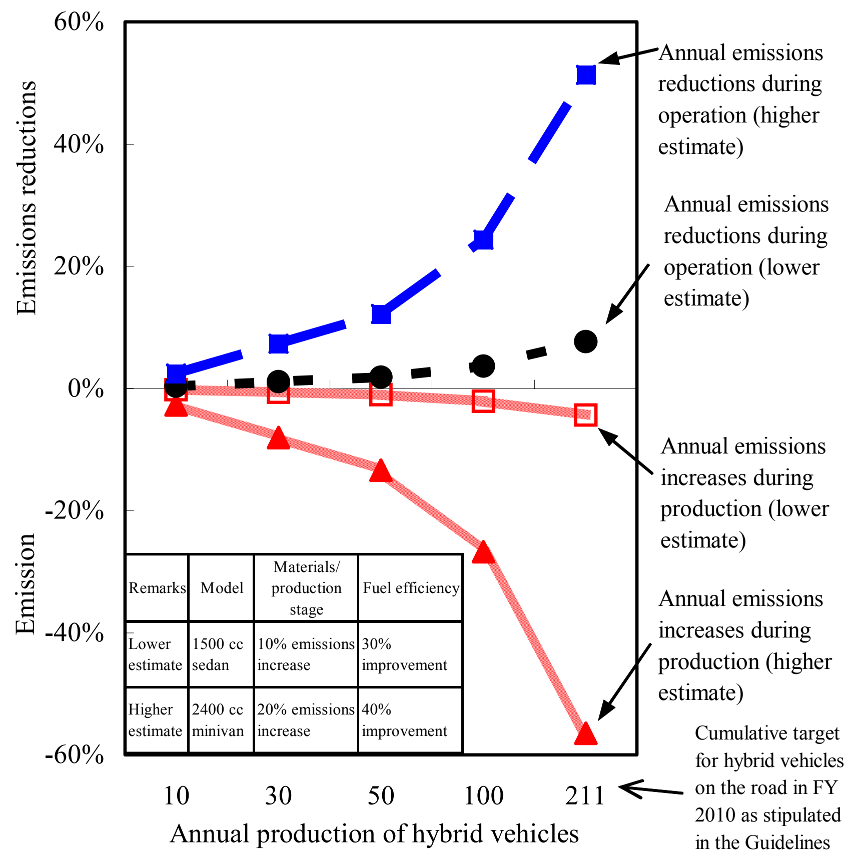
The next caveat relates to the uncertainty of LCA data. LCA figures are extremely difficult to compare, since they vary depending on how data boundaries are set and what the objectives are. In the process of putting together the database, there were many reported cases of the numbers differing by as much as a factor of ten when different companies were asked to provide information on the emissions load from the manufacture of identical products. Comparing LCA data is difficult unless meticulous care is taken to harmonize assumptions like boundaries. Nevertheless, comparing overall trends rather than exact figures is possible; also relatively straightforward is comparing old and new products made by the same company. Steps such as setting appropriate discount rates should go some way to ensuring that the gains from LCA are channeled back to those who bear the costs. Refining LCA methods and data will, it is hoped, reduce margins of error on this front.

A further caveat that should be noted is the time lag and risk involved in the realization of benefits at the LCA level. Environmental load at the usage stage is calculated on the assumption that the product in question will be used for a typical length of time: 100,000 km over ten years for a car, twelve years for a refrigerator, five years for a PC display, and so forth. Therefore, in working out progress in reducing environmental load at the usage stage, account is also taken of emissions reductions five or ten years down the road, not just those for the particular year in question. It is uncertain how the product will be used in the future, and there is no guarantee that it will be used for exactly the length of time assumed; in that sense there is a risk involved in the realization of environmental improvements at the LCA level. Note in particular those cases in which achieving improvements at the LCA level entails increasing current CO_2 emissions at the production stage. Hybrid vehicles and liquid crystal displays are cases in point. Requiring manufacturers to cut emissions at the production stage alone could end up actually thwarting the manufacture and spread of products like these that are desirable for society. In the case of individual products, it is highly uncertain whether the projected benefits can really be achieved. Even so, in the case of items that are fairly widespread throughout Japan, it should be possible to estimate the benefits with a fair degree of certainty, as long as data can be obtained on average number of years of use and conditions of usage. If environmental improvements at the LCA level can be properly assessed, with appropriate discount rates being set based on sampling surveys, it should prove quite feasible to channel the gains back commensurately to companies whose CO_2 emissions have increased at the manufacturing stage.

4-3. The Case of the Hybrid Vehicle

The hybrid vehicle well exemplifies the caveats to LCA use identified in Table 4-3.

The horizontal axis of Figure 4-2 indicates hybrid vehicle production. The vertical axis indicates CO_2 emissions. Today annual production stands at around 50,000 vehicles, but by 2010 it could exceed the million mark worldwide. Japan's policy target as stipulated in the Guidelines for Measures to Prevent Global Warming is to have a cumulative total of 2.11 million hybrid vehicles on the road by FY 2010. This figure of 2.11 million does not represent a single year's production, but it is added to the horizontal axis in order to demonstrate what its impact would be. The vertical axis gives emissions reductions and increases as a percentage of the total of 14.12 million tons of CO_2 emissions generated in FY 2002 by three sectors: automobiles, automobile components, and automobile bodies. The upper half of the graph shows annual reductions in



Remarks	Model	Materials/ production stage	Fuel efficiency
Lower estimate	1500 cc sedan	10% emissions increase	30% improvement
Higher estimate	2400 cc minivan	20% emissions increase	40% improvement

Figure 4-2. Impact of Production and Use of Hybrid Vehicles

Notes: 1. Emissions reductions and increases are given as a percentage of total CO_2 emissions generated in FY 2002 from the manufacture of automobiles, automobile components, and automobile bodies (14.12 million tons).
2. Reductions over the whole lifecycle are tenfold (over ten years).
3. Emissions increases are large because materials other than automobile components are included.

Source: Compiled by DBJ.

emissions from increased hybrid vehicle ownership; the lower half shows increases in emissions at the manufacturing stage. Reductions in emissions occur over a ten-year period and are ten times the numbers shown here -- fifteen times for cars driven in North America and Europe, where a figure of 150,000 km over ten years is used; but here only figures for a single year are shown. The lower estimate given in the graph, based on a 1500 cc sedan, assumes a 10% rise in emissions at the materials production and manufacturing stages, but a 30% improvement in fuel efficiency. The higher estimate, based on a 2400 cc minivan, assumes a 20% rise in emissions at the materials production and manufacturing stages, but a 40% improvement in fuel efficiency. The figures in the lower estimate are fairly firm: they have been worked out based on the estimates of CO_2 emissions calculated in an LCA on a 1500 cc vehicle conducted during Phase I of the LCA Project. The higher estimate has been calculated on the assumption that, in the case of a hybrid minivan, emissions at the materials production and manufacturing stages rise by approximately 20%, which increase is roughly equivalent to the emissions generated during 11,000 km of travel.[48]

[48] In certain cases a vehicle may have to travel some 20,000 km over two years before emissions reductions offset the increase in emissions at the production stage. In these instances the emissions increase may be greater. However, there may be less of an increase in emissions at the produc-

In the case of the lower estimate, emissions do not increase that much even when production reaches the million vehicle mark. Conversely, while emissions reductions do not appear that great in single-year terms, remember that they will increase tenfold over the total of ten years, which yields a fairly impressive reduction of just under 80% at the 2.11 million vehicle level. With the higher estimate, on the other hand, both the increase and decrease in emissions are quite large. The emissions increase crosses the 10% mark at an annual production volume of around 500,000 and rises to almost 30% once production exceeds a million. Annual emissions reductions are likewise fairly large: roughly 10% at the 500,000 vehicle level and over 20% at the million vehicle level. Work out cumulative emissions reductions over ten years, and you get a figure of 1.2 times at the 500,000 vehicle level, and 2.4 times at the million vehicle level. As these estimates demonstrate, it should be possible to achieve emissions reductions that are considerably greater than the automobile industry's total annual emissions.

However, under the current system automobile manufacturers are subject solely to stringent regulations on reducing emissions at the production stage. Although automobiles are subject to Top Runner standards, hybrid vehicles are exempt; so automobile manufacturers tend to be concerned exclusively about the increase in emissions at the production stage. The upshot could be to put a damper on the manufacture of an item that is of benefit to society as a whole.

As pointed out in Table 4-3, there are real uncertainties as to the extent to which emissions reductions can be achieved at the usage stage, since this will vary depending on conditions of use.

The horizontal axis of Figure 4-3 shows the energy efficiency of private automobiles; the vertical axis shows average traveling speed. On the horizontal axis Tokyo is plotted at 1.0, with other locations around the world being plotted relative to that city in order to enable clear comparison. As can be seen from the chart, according to these statistics Tokyo is the least energy-efficient and Copenhagen the most energy-efficient location. The vertical axis gives average speed. Tokyo, along with Paris, clocks in at a mere 25 km per hour or so. Energy-efficient Copenhagen, on the other hand, clocks in at around 50 km per hour. As the chart shows, fuel efficiency and average speed are roughly in proportion: fuel efficiency improves as speed rises. The size of each circle indicates distance traveled per year. The circle for Tokyo, like those for Paris and Singapore, is fairly small; those for Sacramento and other US cities and for Australia are several times larger. Gains in fuel efficiency from driving hybrid vehicles naturally increase the greater the distance traveled per year, but they are also affected by average speed. Hybrid vehicles are designed to keep the engine constantly operating at a high level of efficiency by making efficient use of both the battery and power from the motor; when engine efficiency declines, as during congestion, the motor kicks in. Therefore improvements in fuel efficiency are greater at lower average speeds. Hence hybrid technology is well suited to a city like Tokyo where average speed is low. Emissions reductions at the usage stage are thus affected not just by the amount the vehicle is driven but also by how well the technology matches the particular driving conditions; that makes it difficult to estimate micro level benefits in reducing emissions. On the other hand, for Japan as a whole, the average distance traveled by a passenger vehicle per year remains steady at around 10,000 km, according to such sources as the Annual Statistical Report on Motor Vehicle Transport put out by the Ministry of Land, Infrastructure and Transport. Thus it is possible to come up with an estimate, albeit a rough one, of the benefit in reducing emissions for the country as a whole. In calculating effectiveness in reducing emissions at the LCA level, therefore, one simply needs to properly control such uncertainties.

tion stage due to the effects of mass production, in which case the emissions reductions will be greater. These factors too must thus all be taken into account. In this analysis, an emissions increase of 20% is postulated at the production stage, and it is assumed that the increase and decrease in emissions will even out after 11,000 km of travel.

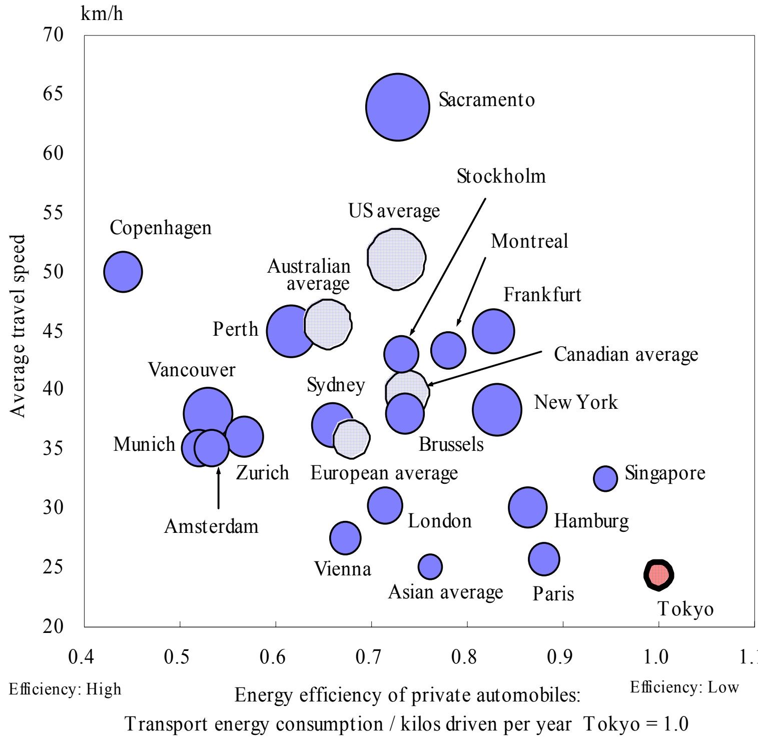


Figure 4-3. Vehicle Traffic Conditions in Major World Cities

Note: The size of the circles represents yearly travel distance. The larger the circle, the longer the distance.

Sources: Compiled by DBJ from data in Japan Transport Policy Research Institute, Automobile Transport Research: The Environment and Policy, 2003.

4-4. Utilizing LCA to Achieve Total Optimization of Global Warming Measures

Figure 4-4 is a conceptual diagram of a scheme for promoting global warming measures that utilizes LCA to achieve total optimization. The vertical axis gives CO_2 emissions; decreases are shown above and increases are shown below. The horizontal axis indicates passage of time. As already described, in the case of liquid crystal displays and hybrid vehicles, emissions rise during production, but life cycle emissions drop overall. Here we postulate an item of this sort that generates increased emissions at the production stage. Those emissions are counted as an emissions increase in the industrial sector. Subsequently annual reductions in emissions are achieved as the product is used from one year to the next. In most instances those reductions are assigned to, say, the transport or commercial and residential sector, rather than to the industrial sector. Volume of emissions reductions at the usage stage varies depending on changes in conditions of use from year to year. It is also affected by errors in LCA data. It should, depending on the product, generally be possible to estimate the product's overall effect in reducing emissions at the macro level based on the average number of years it is used and how it is used. The spread of products that conform to the interests of society can be promoted by properly acknowledging a product's estimated effect in reducing emissions at the LCA level, and channeling back the gains to producers to just such an extent as not to discourage activities that are beneficial from an LCA standpoint. Note that the term "producers" as used here includes manufacturers of components and materials as well as manufacturers in the processing and assembly fields. The gains need to be fairly channeled back to material and component suppliers who

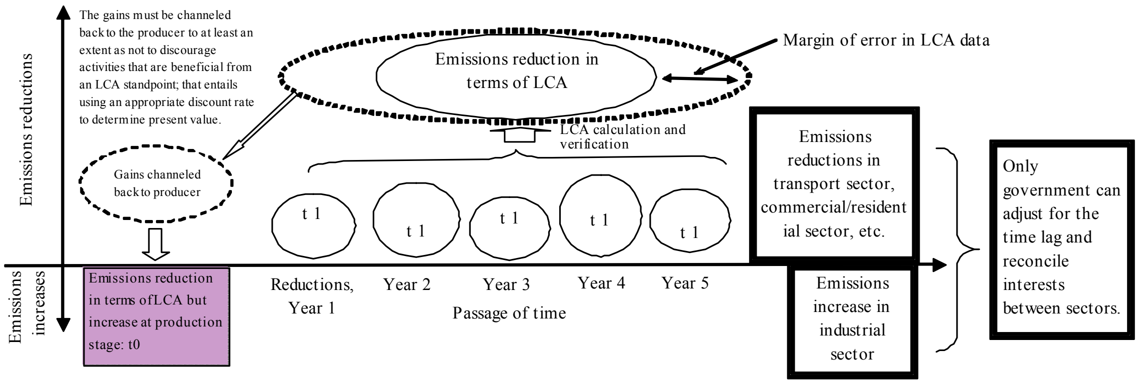


Figure 4-4. Conceptual Diagram of a Scheme for Promoting Global Warming Measures that Utilizes LCA to Achieve Total Optimization

Note: The amount of gains channeled back to the producer needs to be at the minimum >t0. However, if it exceeds t1, the government will in effect be anticipating future emissions reductions until such time as those benefits are realized at the usage stage. Care will then need to be taken to ensure conformity with international treaties.

Sources: Compiled by DBJ.

contribute to the manufacture of energy-saving products.

Only the government sector, as the administrator of the emissions reduction regime, has the ability to make adjustments between sectors and calculate emissions reductions that are going to be achieved in the future. Appropriate government steps are therefore called for. Various specific methods of channeling back gains to producers come to mind. For example, one possibility would be to count the amount in volume of reductions when assessing attainment of targets specified in voluntary action plans, which guide emissions reduction efforts in the manufacturing sector. Or the Top Runner standards could be revised to take account of benefits achieved at the LCA level. Or credits could be issued in the form of LCA emissions rights that could be traded. The emissions rights format would enhance flexibility, thereby further promoting efficient reductions. However, note that if emissions reductions are counted conservatively on the low side in order to eliminate the uncertainties associated with LCA, there will inevitably be a tendency to regard emissions reduction costs as being on the high side. Rather than making the gains tradable in the form of LCA emissions rights, therefore, one conceivable alternative would be to think of them as something else, this with the goal of properly assessing effect in reducing emissions at the LCA level. It would act as an incentive to manufacturers simply to release a range of information on volume of reductions in emissions at the LCA level as computed according to a fixed set of rules, in such a way as to show how much of a contribution each manufacturer has made in quantitative terms. In this case two sets of figures could be posted: reductions in emissions as counted conservatively on the low side, which would be tradable and could be counted towards attaining the reduction targets stipulated in the company's voluntary action plan; and non-tradable emissions reductions as calculated simply without taking too much account of other factors.

Figure 4-5 illustrates the future of the LCA as a means of enhancing the fight against global warming. LCAs come in many shapes and sizes. Today most LCAs concern themselves solely with products, but there are also LCAs that cover the full range of corporate operations. Some LCAs confine themselves to Japan because of problems with collecting data and so forth; others gather data from far and wide overseas. Some focus exclusively on CO_2; others cover a wide range of substances, including CFCs and particulate matter discharged into the atmosphere, and BOD and other substances discharged into

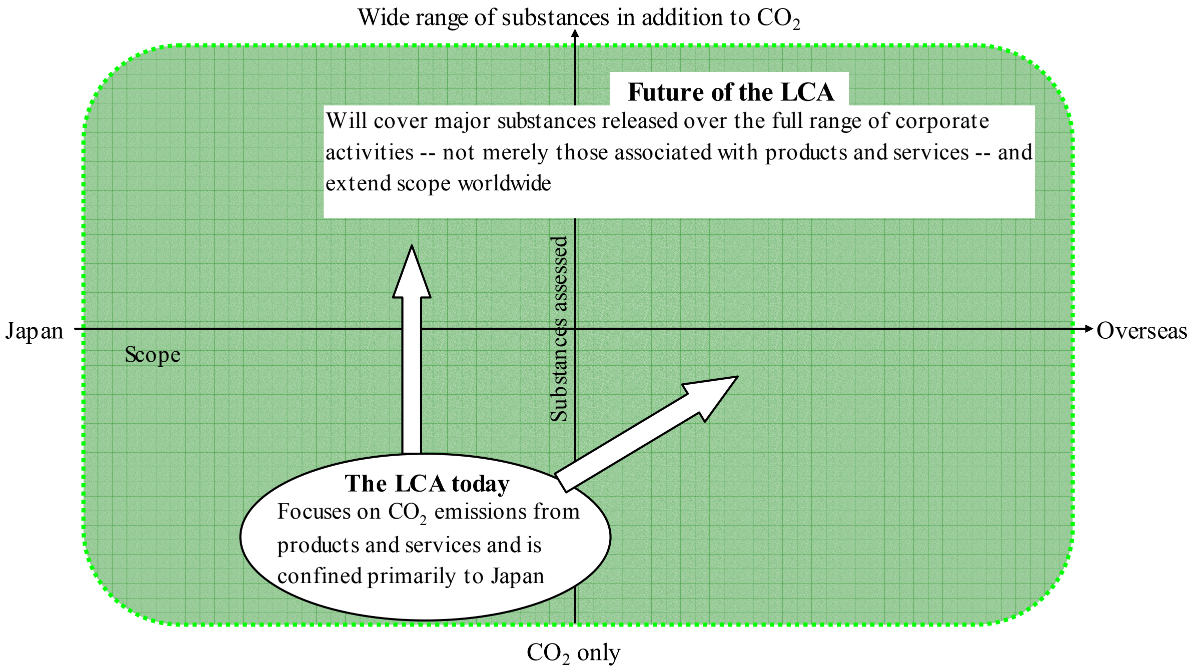


Figure 4-5. Future of the LCA as a Means of Enhancing the Fight against Global Warming

Sources: Compiled by DBJ.

the hydrosphere. This paper has concentrated primarily on LCAs that collect data solely within Japan and focus on CO_2 emissions from products and services, which at the present stage constitute the most straightforward type of LCA to handle. However, the LCA of the future will ideally be as illustrated in Figure 4-5: it will cover all major substances released over the full range of corporate activities -- not merely those associated with products and services -- and extend its scope worldwide. Only then will it be possible to implement a global warming strategy capable of managing discharged substances in optimum fashion. Today, with the economy becoming so globalized, confining one's perspective to the domestic scene is not going to produce truly meaningful measures to combat global warming. Rather than letting national borders get in the way, it is to be hoped that advantage can be taken of LCA to determine, from a global perspective, what efficient, effective measures exist for reducing emissions at each stage; in that way appropriate steps can be implemented to cut emissions. Putting such a global strategy into action will make it possible to prevent the problem of carbon leakage[49] caused by the fact that the Kyoto Protocol covers only 10-30% of the world's total emissions flow. It will also reduce the distortion to competition caused by the way that the need to take global warming measures differs in degree depending on the location of the factory.

Table 4-4 summarizes the primary LCA activities being undertaken in APEC countries based on the results of a questionnaire. While it may be presumed that the answers are affected to some extent by the subjectivity of the respondents, this chart does provide a general idea of the situation in each country.

A glance down the chart reveals that virtually all the countries in question have performed case studies on LCA in some form or another. Many of them have made progress in developing

[49] The leakage of benefits in reducing CO_2 emissions caused by the relocation of factories and production from regions that require reductions in greenhouse gases to those that do not (in the case of the Kyoto Protocol, the developing countries or the US, for example). See Aiba (2003).

databases,[50] although a few simply take over EU data wholesale. Government support is the exception rather than the rule, but it is provided in those countries where LCA activities have made the most headway; this shows that there is a certain correlation between progress in LCA and availability of government support. Many countries are engaged in developing LCA techniques; some even attempt to conduct their own independent impact assessments. Then comes the question of use of LCA by industry. Although there are not that many countries where LCA is widely used by industry, large corporations in particular do utilize it in many countries, including developing ones. Type III ecolabel certification is being sought even in Thailand, Malaysia, and Indonesia, according to the survey responses. In the areas of simplified LCAs, DfE,[51] domestic standards, and green purchasing, countries such as Japan, Taiwan, and South Korea have been making the most progress. Taiwan and South Korea are in overall terms taking similar action to Japan. Hence a wide range of LCA activities are being implemented in the APEC countries, including the developing ones. In the future it should thus be possible to implement LCAs on a global scale and execute effective, efficient measures to combat global warming from a global standpoint.

[50] Switzerland has constructed a fairly advanced national database, which there is not space to describe in detail here. The Ecoinvent 2000 database, which was put together between 2000 and 2003, contains some 2,600 data items on such matters as energy, construction materials, metals, chemicals, pulp and paper, waste materials, agriculture, etc. This is a fairly advanced database, even considering the relative ease of collecting data in such a small country.

[51] Design for Environment.

Table 4-4. Primary LCA Activities Being Undertaken in the APEC Countries (Results of a November 2002 Questionnaire)

Country	Case studies	Developed LCA database?	When database developed, what information collected	Uses EU database?	Govern-ment support	Developed LCA techniques?	Individual impact assessment	LCA used by industry?	Using Type III ecolabel to promote LCA?	Simplified LCA	DfE (Design for Environment)	Domestic standards	Green pur-chasing
Japan	Assembled/finished goods, raw materials, energy, services, etc.	○	1998-2002 550 items including materials, energy, assembly, disposal, recycling, etc.		○	○	○	In widespread use	○		○	○	○
Taiwan	Trade goods, e.g., electrical appliances and electronic devices etc.	○	1996-2000 Water supply, electric power, petrochemicals, steel, non-ferrous metals, rubber, semiconductors, etc.		○	○	○	In widespread use		○	○	○	○
South Korea	Assembled/finished goods, raw materials, waste management, etc.	○	1998-2003 Materials, energy, transport, waste processing, etc.		○	○		Mainly by large corporations	○	○	○		○
United States	No response	○	2001-2005 Plastics, metals, etc.			No response	○	No response			○		
Thailand	Electrical and musical products etc.	○		○		×		In major industries	○				
Malaysia	Waste management, farm products, raw materials, etc.	○				×		Mainly by large corporations	○			○	
Indonesia	Oil, coal, metals, etc.	○				×		Not actively	○				
Brazil	Waste management, farm products, etc.	×		○		×			○				
China	Resources, e.g., steel, aluminum, nickel, glass, cement, chemical compounds, services, etc.	No response				○	○	In widespread use					
Australia	Waste management, construction, assembled/finished goods, etc.	○			○	○		Mainly by large corporations					
Canada	Metal products, soil improvement, etc.	○				○	○	Mainly by large corporations					
Mexico	Farm products, plastic products, etc.	○				×		Mainly by large corporations				○	
Chile	Metals, forestry, etc.	No response				○		Mainly by large corporations					
Singapore	Electronic products, raw materials, chemicals, etc.	○				×		Mainly by multinational corporations					
India	Paper, waste management, power plants, etc.	×				×		Mainly by large corporations					
Philippines	Paper, detergent, etc.	No response				×		×					

Sources: Compiled by DBJ from, among other sources, handouts accompanying two presentations: one by Dr. Sagisaka of the National Institute of Advanced Industrial Science and Technology (AIST), given at the Symposium on Current Status and Future Tasks for LCA Research in the World held Feb. 17, 2004, and the other by Dr. Atsushi Inaba of the AIST given at a LCA Japan Forum seminar on Mar. 18, 2004.

Conclusions

As this survey has shown, the LCA perspective is useful in fostering effective, efficient implementation of global warming measures. While LCA techniques remain underdeveloped in certain regards, Japan's LCA infrastructure has evolved dramatically in the past few years thanks to METI-NEDO projects and the like; it is now entering the phase where it can be put to practical use. Further government support would be welcome, for public assistance is still needed to promote development of the required infrastructure in such areas as setting up a data collection regime, making practical use of LCA, and implementing legal regulatory measures. Attempts to implement LCAs and internalize external costs are in the interests of society as a whole, but the private sector cannot really do the job alone, since collecting and processing information entail considerable costs. The private sector will take action of its own accord basically in those cases where collecting, processing, and disclosing data is consistent with its own aims. Without prodding, therefore, it may make no progress in disclosing data where it is in the greater interests of society. LCA information is of the character of a public asset necessary to ensuring that resources are allotted as best for society as a whole. It is to be hoped that a proper system for gathering and utilizing information will evolve.

The amount of LCA information that can be directly compared is increasing thanks to, for instance, the advent of the Type III ecolabel. However, LCA information is largely meaningless on its own. It only assumes true significance when harnessed by manufacturers to improve product design or by consumers to make purchase choices. Efforts should be made to further enhance utilization of LCA information on the consumer side; companies releasing data should for their part make the disclosed information easier to understand by, for example, using a rating system. The most critical thing of all is for manufacturers to make use of LCA information in design for environment (DfE). Europe is putting legal regulations in place with that in mind. But, given the nature of LCA information disclosure and utilization, and the additional costs that they entail, a regulatory approach could well end up discouraging companies that are making a serious effort, especially under present conditions, where no system exists to ensure that the benefits of improvements at the LCA level are channeled back to the manufacturer through product pricing or whatever. Indicators of environmental impact at the LCA level may in certain cases actually rise if a company seriously spends money on gauging that impact across as broad a front as possible. Conversely, a company may maliciously underreport the results of its calculations. Moreover, the data collection methods involved are so complex that it is very difficult to conduct exhaustive verification from outside. Given the fact that LCA information is of such a nature, the best way to encourage its use would be a system incorporating positive incentives that make it to a company's advantage to be serious about disclosing and upgrading LCA information.

As we observed in the case of hybrid vehicles and liquid crystal displays, there is a fairly serious problem with the discrepancy between who bears the cost of improvements at the LCA level and who reaps the benefits. Reconciling interests over time and across different sectors is not something that companies can do individually; it will require appropriate policy guidance. Ideally, the costs to society as a whole of fighting global warming should be minimized by issuing LCA emissions rights for cuts in emissions achieved at the LCA level; these would be tradable with other emissions rights obtained through various cuts in emissions. That would encourage innovation and development of more desirable technologies.

Making appropriate use of LCA would give manufacturers and other businesses far more leeway to fight global warming and enable them to implement flexible, effective measures on that front. It would also fully tap the potential that business possesses in the form of its considerable management capacity and wealth of management resources. Action at the LCA level would also be effective for society as a whole. The government should develop the proper infrastructure and offer appropriate incentives. LCA, one hopes, will contribute to the total optimization of global warming measures on a global scale.

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