Outline of T-E2A

(T-E2A: Toray Eco-Efficiency Analysis)

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Introduction

T-E2A, an abbreviation for Toray Eco-Efficiency Analysis, is an environmental analysis tool designed for plotting the environmental loads and economic efficiency of different products[*1] into a chart to identify the best product that has a less load and higher efficiency.

This booklet provides information about the concept of the T-E2A software which has been developed and publicized as an extended-function version of the MiLCA[2)] support software for LCA[1)*2] of the Japan Environmental Management Association for Industry. The association hopes that T-E2A will be broadly understood and used in not only developing eco-friendly products but also in disclosing environmental information for consumers and making decisions where the environmental consideration is a must.

*1 The 'T-E2A products' referred to here are products based on case studies. They are simply called 'products' herein.

*2 LCA or Life Cycle Assessment is a method or tool to quantitatively evaluate the environmental impact imposed on the earth and ecological systems by the resources used in a product during its life cycle. LCA is designed to improve the environmental aspect of products or services.

Contents

1. Information about T-E2A

T-E2A is an environmental analysis tool that helps compare and evaluate the environmental loads and economic efficiency of different products or processes each other that are plotted on an ‘Eco-Map’ (Figure 1) so that a product with a less load and higher efficiency may be chosen.

T-E2A features in particular the following 4 functions:

[1] comprehensive evaluation of the environmental and economic aspects of a product or a process based on a case study carried out by the user;

[2] evaluation from the end user’s viewpoint and about the product’s total life cycle;

[3] representation in an ‘Eco-Map’ made of two axes, environment (vertical) and economy (horizontal), and

[4] stability evaluation of results by sensitivity analysis under the condition of multiple weighting.

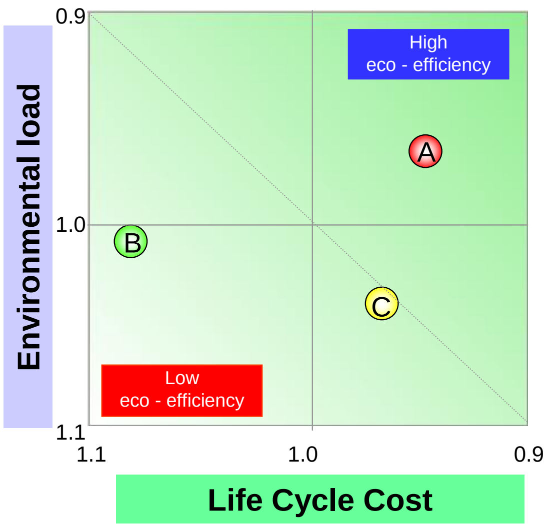

Figure 1 ‘Eco-Map’

(See Section 4.3 for information about the ‘Eco-Map’.)

2. Environmental impact categories

T-E2A covers the following 7 categories of environmental impact.

[1] Energy resource

[2] Mineral resource

[3] Water resource

[4] Land use

[5] Emission (Air, Water, and Soil)

[6] Toxicity potential

[7] Risk potential

Although discussing global environmental problems would often focus on CO2 that induces global warming, there may also be other important factors that can impose loads on the environment.
So, evaluating environmental impact only by one kind of load may allow other more important loads to slip off resulting in the wrong conclusion where the bad can be taken for the good (trade-off between the environmental impact categories[1)]). To prevent this from happening, LCA employs weighting and integration between the different impact categories. Furthermore, T-E2A includes potential toxicity and potential risks as analysis subjects, which are not contained in LCA, to make the assessment by T-E2A extra comprehensive.

2.1. Energy resource

In the energy resource category, T-E2A calculates the total energy amount consumed during the life cycle of a product, based on the calorific value generated from fossil resources. In Figure 2 below, for example, assume the energy consumption of the product at each of the materials acquisition, manufacture, use and disposal stages in terms of electric power to be 1, 2, 0.1, and 0.4 megajoule (MJ), respectively, the product's total energy consumption would be 3.5 MJ.

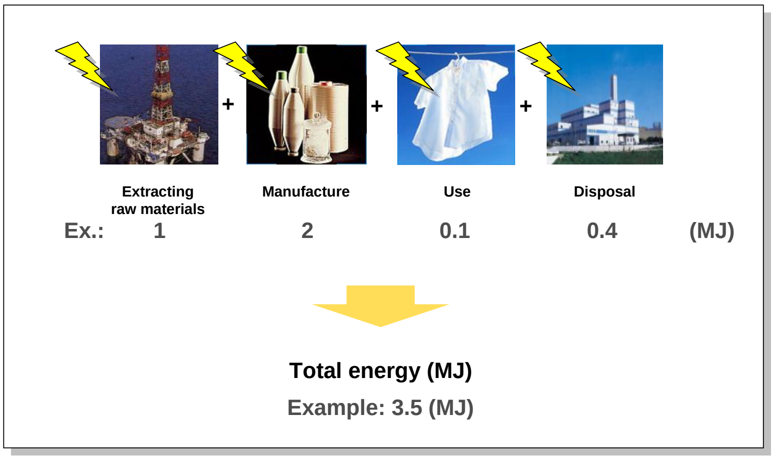

Figure 2 Concept of the total energy consumption

2.2. Mineral resource

In this category, the mineral resource consumption of a product during its total life cycle will be calculated. The mineral resource represents all useful minerals including antimony, tungsten and zinc. In calculation, the amount to be calculated should be weighted with a reciprocal of the amount of recoverable reserves of the mineral normalized by antimony. See Reference 3) for detailed information about the calculation concept[3)]. To avoid double counting with the Energy Resource consumption, petroleum, coal and natural gas are not included in the mineral resource.

2.3. Water resource

The total water resource consumption during a product's life cycle is calculated. T-E2A thus evaluates the water resource as an independent environmental impact category. The water referred to here is freshwater. For the characterization factor, sampling the water other than seawater is evaluated as one (1) and that of seawater, zero (0).

A global water shortage is in progress due to a water demand boost caused by the recent global population explosion and industrialization. According to the 2006 IWMI* report[4)], 1.1 billion out of the global 6.5 billion people have failed to obtain enough household water including drinking water. Since the situation is expected to get worse, the water resource is an important factor, as is the energy resource or the air pollution.

* International Water Management Institute

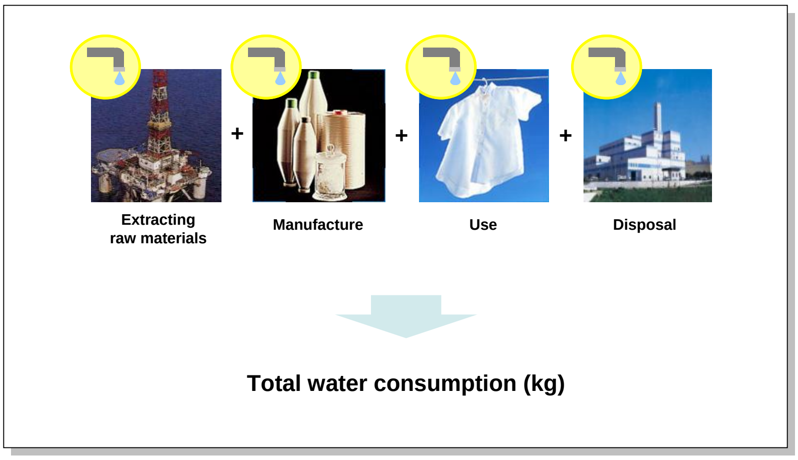

Figure 3 Concept of the total water consumption

2.4. Land use

T-E2A considers the maintenance of land and evaluates a product by the area and time length exclusively used by the product during its life cycle. In characterizing the environmental impact, land usage may be simply totalled in disregard of what it is used for. For example, in case of (1) a 100 m^2 construction site occupied 5 years and (2) a 20 m^2 final disposal site occupied 30 years, the latter is supposed to have a higher environmental load (See the formulas below).

(1) construction site $100\ m^2 \times 5$ years = $500\ m^2$·years.......... [F1]

(2) final disposal site $20\ m^2 \times 30$ years = $600\ m^2$·years.......... [F2]

Land is an intrinsically limited resource and subjected to a T-E2A analysis because inappropriate land use could result in deforestation and desertification that would cause environmental problems such as vegetation and ecosystem damages. Since the Japanese archipelago has a large population in a small habitable land area, collision of interest between land users can cause various underlying problems to the environment[3)].

2.5 Emission (Air, Water and Soil)

Emission will be separately evaluated in three categories, emission into the air, the water and the soil. These categories will be integrated on the basis of the weighting concept described in Section 3.1 below.

(1) Emission into the air

Emission into the air will be separately weighted in accordance with the following 4 subcategories:

[1] Global warming potential (GWP)

[2] Ozone-layer depletion potential (ODP)

[3] Photochemical oxidant creation potential (POCP)

[4] Acidification potential (AP)

(2) Emission into the water

Emission into the water will be assessed by evaluating how much the emitted substance affects the water. For weighting, T-E2A sets as a factor the reciprocal of a regulated drainage value (the maximum allowable concentration of a chemical substance or substances discharged into the water) as provided by law[5]. The answer from there will be multiplied by the emitted amount of the chemical substance in question to evaluate its impact. For example, if the maximum allowable biochemical oxygen demand (BOD) is an average 120 mg/liter per day, the weighting factor will be 0.0083 litre/mg. Assume a product emits 10 mg/liter BOD during its life cycle, its impact of emission to the water would be 0.083 points.

(3) Emission into the soil

Emission into the soil is calculated by evaluating the impact of landfill waste. As Table 1 shows, the characterization factors are defined on the basis of nonindustrial waste. The impact level of waste is calculated by multiplying the amount of the waste in question by one of the factors.

Waste is sorted largely into industrial waste, nonindustrial waste, and intensively controlled industrial waste. Industrial waste includes 20 items defined by the Waste Disposal Law out of the waste produced in industrial activities, while intensively controlled industrial waste is the industrial waste that can be hazardous to people's health and living environment. Waste belonging to neither of them is defined as nonindustrial waste.

Table 1 Waste classifications and characterization factors

Classifications	Characterization factors
Nonindustrial waste	1
Industrial waste: 20 items including debris, rubber chips, soot and dust, sludge, metal chips, mixed construction waste, slag, wastepaper, cinder, waste fiber, earth and gravel, etc.	2
Intensively controlled industrial waste	5

2.6 Potential-toxicity assessment

Potential toxicity shall be defined as shown by the formula 3 below.
For assessment, the analyst is supposed to assume the potential toxicity on his/her own and set impact points for the products in question.

(Potential toxicity) = (Potential toxicity of substance) × (Exposure frequency) ....[F3]

Concerning exposure, weighting may be defined for each stage of the life cycle, that is, product manufacture, use, and disposal as waste, by means of setting a period factor. In the case of a product providing the end user with a long-time use, weighting factors may be set for 70% for use, 20% for manufacture, and 10% for waste disposal.

As for the potential toxicity of a substance itself, it may be assessed by using the Risk Phrases, a classification code system set forth by the European Union about the risks of toxic chemicals.

Although a potential toxicity evaluation shall not be carried out in accordance with the ISO-based LCA, T-E2A evaluates it as a factor equally important to the other environmental impacts, such as energy resource and air pollution.

2.7 Potential-risk assessment

Potential risk shall be defined as shown in the Formula 4 below.
As in the case of potential toxicity mentioned in the foregoing section, assessment of a potential risk shall be assumed by the analyst himself/herself and points set for the subject products.

(Potential risk) = (Potential-risk seriousness) × (Incidence) ....[F4]

Risk element examples are given below:

- explosion, fire (handling of flammable/combustible materials);
- product misuse;
- traffic accident during transport (volume, weight, etc.);
- adverse effects on manufacturing workers and working environment, and
- product refilling/packing risk.

As in the case of potential toxicity, potential risk evaluation may not be conducted under the ISO-based LCA but T-E2A performs it as an important factor in comprehensibly assessing a product or a process.

3 Weighting the impact categories

The environmental impact categories stated above shall be integrated into one in accordance with the concept of weighting by social factors and scientific factors. These weighting factors are designed to be chosen or changed pursuant to environmental problems and/or regional conditions so a sensitivity analysis may be carried out under more than one weighting conditions.

3.1 Weighting by social factors

Weighting the environmental impact categories by social factors shall be carried out by setting importance levels judging from public opinion, consumer trends and other social concern made known through interviews and questionnaires on specialists (Table 2). This is because the focus on various environmental issues, such as air pollution, water pollution, waste disposal, etc., may change in relation to changes in social awareness, administrative policies and corporate activity regulations. Assuming a social condition, for instance, where greenhouse gas emission regulations would be tightened as part of countermeasures to global warming, you may set a higher weight on the global warming potential (GWP). Likewise, a higher weight may be given to the energy resource impact under a social situation where energy saving is considered additionally important in view of the recent energy shortages.

Table 2 Example of weighting by social factors

			Importance	Weighting factor
Mineral resource			10	0.10
Energy resource			25	0.25
Water resource			10	0.10
Land use			5	0.05
Emission	Air	Global warming	15	0.15
		Ozone depletion	6	0.06
		Photochemical oxidant	6	0.06
		Acidification	3	0.03
		Emission (air) subtotal	30	0.00
	Water		7	0.07
	Soil		3	0.03
	Emission (all) subtotal		40	0.00
Toxicity potential			3	0.03
Risk potential			7	0.07
Total			100	1.00

The weighting factors on Table 2 are default values set by Toray, which may be changed following assessment.

3.2 Weighting by scientific factors

Weighting by scientific factors is to indicate a regionally intrinsic importance level for each environmental impact. A scientific factor shall be calculated using a relative ratio obtained by dividing the environmental load of the product in question by the total environmental load based on the statistical data of the region or the country concerned[6)].

The countries/regions for which the statistical data are available include Japan, Germany, U.S.A., U.K., EU, China and South Korea. In using these data, please note that the data from China and South Korea about SO_4 ion and NH_4 ion emissions into the water are only estimated data although those about CO_2, NOx, and SOx emissions into the air are actual. All these statistical data will be updated and complemented from time to time.

4. ‘Eco-Map’

Results from a T-E2A analysis shall be charted into an ‘Eco-Map’ which plots the product’s environmental load on the vertical axis and the product’s life cycle cost on the horizontal axis.

4.1 Concept of the vertical axis

Normalization results of an analysis of different products for the 7 environmental impact categories will make a 7-axis radar chart representing ecological fingerprints (detailed below). The chart, with an inter-category weighting by social factors, will be integrated into a single environmental impact index. The ‘Eco-Map’ vertical axis is made of these single indices of products, normalized and aligned (Figure 4). In this map, a category with lower impact on the environment is plotted in an upper position.

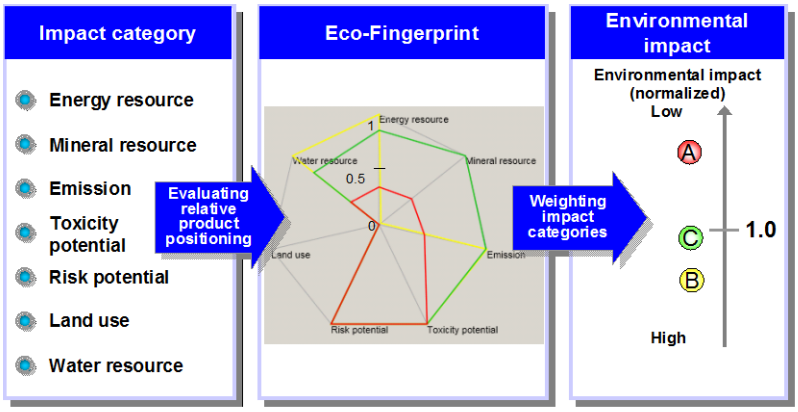

Figure 4 Concept of the ‘Eco-Map’ vertical axis

The ecological fingerprints ('Eco-Fingerprints') referred to here shall be obtained in the following manner:

As shown in Figure 5 below, normalize each of the 7 impact categories and plot the relative impact levels of respective products in a range of 0 to 1. The product with the highest environmental load among all evaluated products is plotted for 1 while the one with the lowest load, for 0. In other words, higher loads are fingerprinted in the outer positions on the radar chart and lower loads, in the inner positions. As Figure 5 shows, in the Emission category, product D has the highest environmental load, followed by products A, E, and C, in that order, and product B imposes the lowest load on the environment.

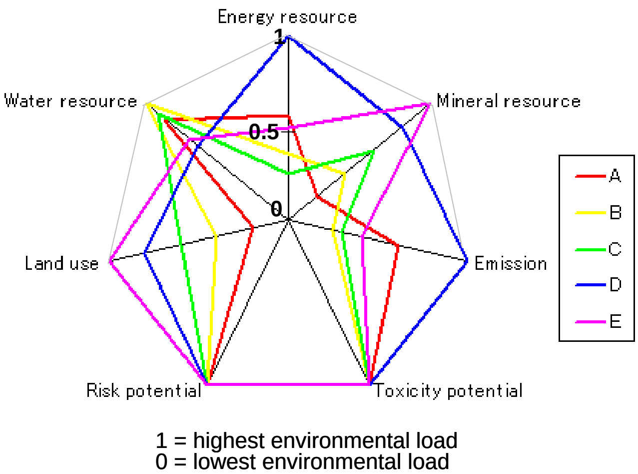

Figure 5 'Eco-Fingerprints'

4.2 Concept of the horizontal axis

Economic efficiency handled by T-E2A represents the life cycle cost (LCC) of a product viewed from the end-user's standpoint. The horizontal axis of an 'Eco-Map' denotes the LCCs of evaluated products, normalized and aligned. A product with a lower LCC is plotted to the further right-hand side of the chart (Figure 6).
LCCs may be calculated beforehand and entered by the analyst in the T-E2A's LCC input window. In general, an LCC may be calculated in the following manner:
Identify and define the end user for the product or service put to the LCC analysis. Then, calculate the user's expenditure, ranging from the initial investment, running costs and disposal expenses, as done in a life cycle assessment (LCA), and sum them up as the user's LCC. Since LCC calculation and the outcome thereof may thus change in accordance with the definition of end users, they should be properly chosen pursuant to analysis purposes and product characteristics. Take an automobile for example, define an ordinary consumer as the end user, the buying price of the car as the initial investment, the petrol buying prices as the running costs to calculate the user's LCC.

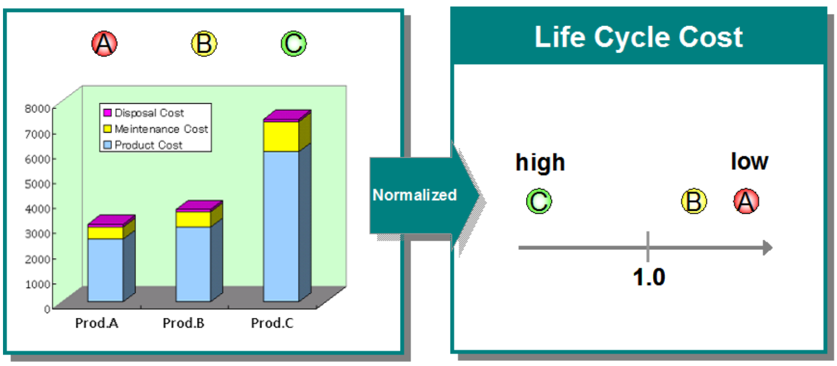

Figure 6 Concept of the 'Eco-Map' horizontal axis

4.3 Interpreting an ‘Eco-Map’

An ‘Eco-Map’ is drawn in accordance with the above-mentioned concept of the vertical and horizontal axes. The map visualizes the environmental and economic positions of different products by plotting their ecological efficiency in relevant positions in the chart.
A product with a lower environmental load may be plotted in the map’s upper part and a product with a lower economic burden is plotted to the right-hand side of the map. Put differently, a product plotted in the upper right-hand area in the map and further from the diagonal line may be regarded as having higher ecological and economic efficiency and a lower environmental load. In Figure 7 below, product A may be regarded as having high ecological efficiency while product B, though inferior to product C in terms of environmental efficiency, may be economically competitive enough to be optimized.

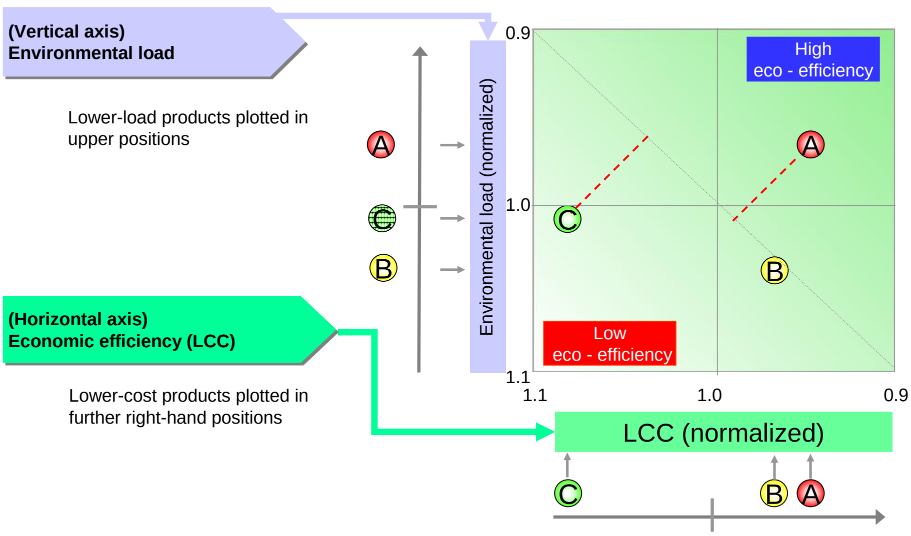

Figure 7 Interpreting an ‘Eco-Map’

5 Making good use of T-E2A

T-E2A is useful in multiple cases including corporate management, research and development, production, marketing and corporate publicity. It is also helpful in providing important decision-making data when a new investment plan or an enterprising scheme is discussed. Among others, using the T-E2A methodology on the initial R&D stage to produce a new product or a new process will help secure permanent competitiveness for the product or process which will become most viable both in the environmental and economic aspects.

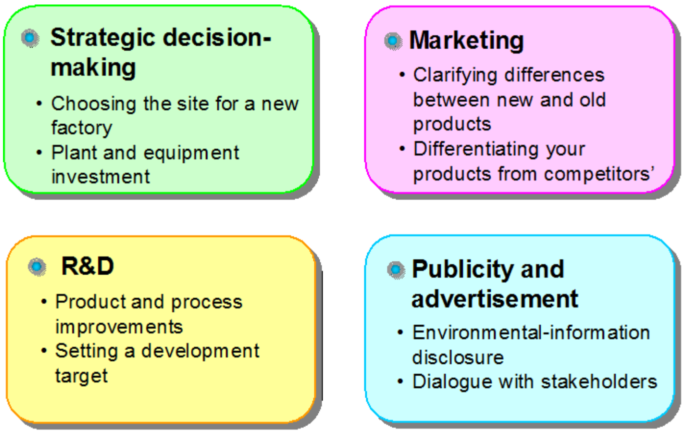

Figure 8 Making good use of T-E2A

6 References

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2) 'New LCA Software MiLCA', JEMAI.
3) 'LIME 2: Environmental Impact Assessment Methodology to Support Decision-Making', JEMAI.
4) 'IWMI Report' (2006), International Water Management Institute.
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6) pp1-19, 'Eco-efficiency Analysis by BASF-Calculation Procedure Following the Original ', Karl-Heinz Feuerherd, Seminar Materials Series No. 3 E (2003), Kobe Yamate University.