Summary

The Eco-costs/Value Ratio, EVR

The basic idea of the EVR (Eco-costs/Value Ratio) model is to link the ‘value chain’ (Porter, 1985) to the ecological ‘product chain’. In the value chain, the added value (in terms of money) and the added costs are determined for each step of the product “from cradle to grave”. Similarly, the ecological impact of each step in the product chain is expressed in terms of money, the so-called eco-costs. See Figure A.

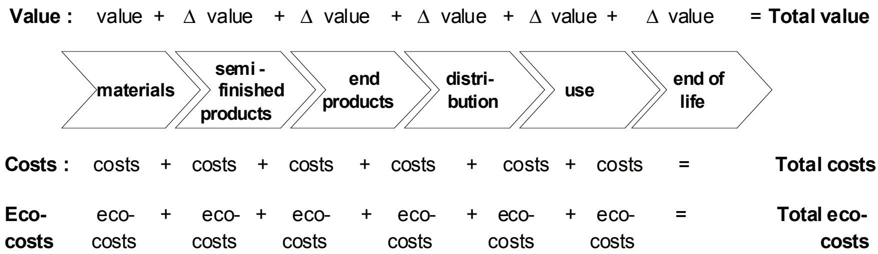


Figure A. The basic idea of combining the economic and ecological chain: “the EVR chain”.

The eco-costs are ‘virtual’ costs: these costs are related to measures which have to be taken to make (and recycle) a product “in line with earth’s estimated carrying capacity”. These costs have been estimated on the basis of technical measures to prevent pollution and resource depletion to a level which is sufficient to make our society sustainable.

Since our society is yet far from sustainable, the eco-costs are ‘virtual’: they have been estimated on a ‘what if’ basis. They are not yet fully integrated in the current costs of the product chain (the current Life Cycle Costs). The might be regarded as ‘hidden obligations’.

The ratio of eco-costs and value, the so-called Eco-costs/Value Ratio, EVR, is defined in each step in the chain as:

$$EVR = \text{eco-costs} / \text{value}$$

For one step in the production+distribution chain, the eco-costs, the costs and the value are depicted in Figure B.

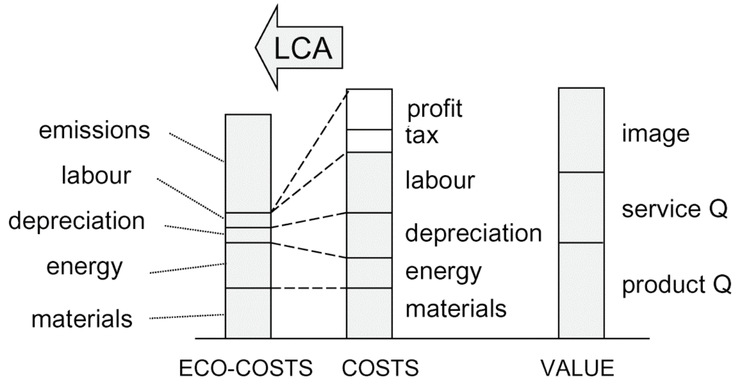


Figure B. The decomposition of "virtual eco-costs", costs and value of a product.

The five components of the eco-costs have been defined as 3 'direct' components plus 2 'indirect' components:

1 virtual pollution prevention costs, being the costs required to reduce the emissions of the production processes to a sustainable level (Chapter 2)
2 eco-costs of energy, being the extra price for renewable energy sources
3 materials depletion costs, being (eco-costs of raw materials)$\times(1 - \alpha)$, where α is the recycled fraction
4 eco-costs of depreciation, being the eco-costs related to the use of equipment, buildings, etc.
5 eco-costs of labour, being the eco-costs related to labour, such as commuting and the use of the office (building, heating, lighting, electricity for computers, paper, office products, etc.).

Based on a detailed cost-structure of the product, the eco-costs can be calculated by multiplying each cost element with its specific Eco-costs/Value Ratio. These specific EVRs have been calculated on the bases of LCAs. Tables are provided for materials, energy and industrial activities. See www.ecocostsvalue.com tab data.
(See Chapter 3.)

The pollution prevention costs

The aforementioned pollution prevention costs are being calculated in four steps:

1. LCA calculation according to the current standards (ISO 14040 and 14044)
2. Classification of the emissions in 7 classes of pollution
3. Characterization according to characterization multipliers as used in e.g. the Eco-indicator '95, resulting in "equivalent kilograms" per class of pollution
4. Multiplication of the data of step 3 with the 'prevention costs at the norm' ,being the marginal costs per kilogram of bringing back the pollution to a level "in line with earth's carrying capacity".

The following 'prevention costs at the norm' are proposed for The Netherlands and Europe:

1	prevention of acidification	7.55 €/kg SOx equivalent
2	prevention of eutrophication	3.60 €/kg phosphate equivalent
3	prevention of ecotoxicity (heavy metals)	802 €/kg Zn equivalent
4	prevention of carcinogens	33 €/kg PAH equivalent
5	prevention of summer smog	8.90 €/kg C_2H_4 equivalent
6	prevention of fine dust (winter smog)	27.44 €/kg fine dust PM2.5
7	prevention of global warming	0.135 €/kg CO_2 equivalent.

These 'prevention costs at the norm' are based on the so-called 'marginal prevention costs' of emissions. The way these marginal prevention costs are determined is depicted in Figure C. For each type of emission, the costs and the effects (in terms of less emissions) are accumulated for several prevention measures to be taken (a 'what if' calculation). At a certain point on the curve, the 'norm for sustainability' is reached. The marginal prevention costs are defined by the costs per kg reduction of the 'last' measure, depicted as line b.
The 'norms for sustainability' are based on the 'negligible risk levels' for concentrations (in air and in water).

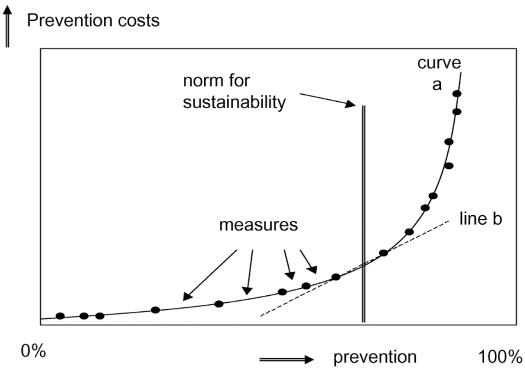


Figure C. The way the marginal prevention costs are calculated from emission prevention measures for a certain region.

(See Chapter 2)

The End of Life stage and recycling: Cradle to Cradle

The End of Life systems are rather complex. For complex products, like buildings, there are many different system opportunities to make the solution more sustainable (from recycling to enhancement of the durability).
Figure D depicts the major types of End of Life treatment and types of recycling. It is developed to describe and analyse the various kinds of complex modern life cycles of consumer products, buildings, manufacturing plants, civil structures, etc.

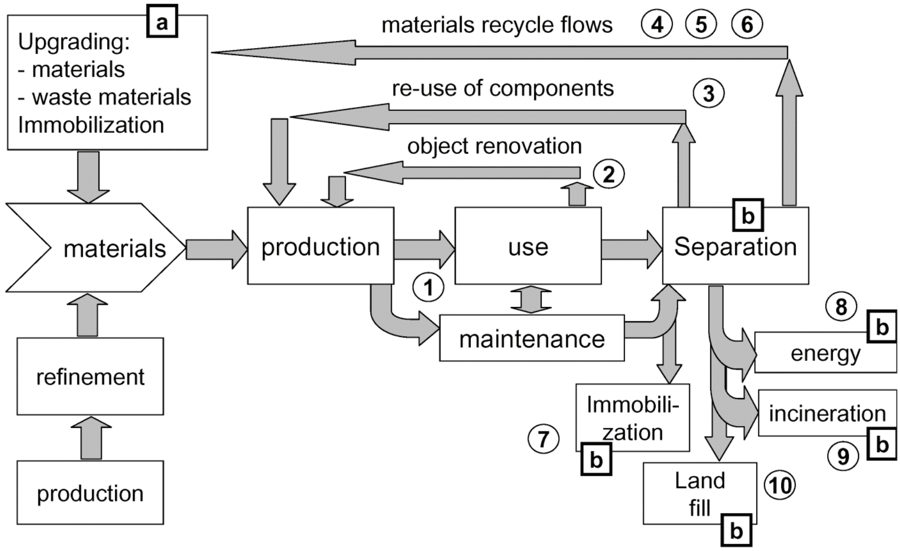


Figure D. The flow of materials in the Life Cycle.

The numbers in Figure D relate to the "Delft Order of Preferences"[84], a list of the 10 major systems for End of Life, used for structured and systemized analyses of (combinations of) design options:

1. Extending of the product life
2. Object renovation
3. Re-use of components
4. Re-use of materials
5. Useful application of waste materials (compost, granulated stone and concrete, slag, etc.)
6. Incineration with energy recovery
7. Immobilization with useful appliances
8. Incineration without energy recovery
9. Immobilization without useful appliances
10. Land fill.

It is important to realize that for big, modular objects (like buildings), there is not "one system for End of Life" but in reality there is always a combination of systems.
Two basic rules for allocation in the EVR model are:

1 Costs and eco-costs of all activities marked with 'b' are allocated to the End of Life stage of a product (transportation included).
2 Costs and eco-costs of all activities in the block marked with 'a' are allocated to the material use of the new product (so are allocated to the beginning of the product chain).

[84] In 2007 the order of numbers 6-9 was slightly changed (incineration was placed higher than immobilization, because of the positive effects in LCA calculations)

In line with the aforementioned allocation strategy, the 'bonus' to use recycled materials is taken at the beginning of the product chain, where the new product is created. Material depletion is caused here when 'virgin' materials are applied, material depletion is suppressed when recycled materials are applied.
(See Chapter 4)

Ecoefficient value creation

Product designs for the future will need to combine a high value/costs ratio as well as a high eco-efficiency.
The advantage of the EVR model is that it can reveal how the de-linking of economy and ecology can take place in practical situations.

For designers, the EV Wheel has been developed, showing the strength and weakness of a certain design on the value side as well as the eco-costs side. See Figure E. A sustainable design is characterized by high scores at the value side and low scores at the eco-costs side.

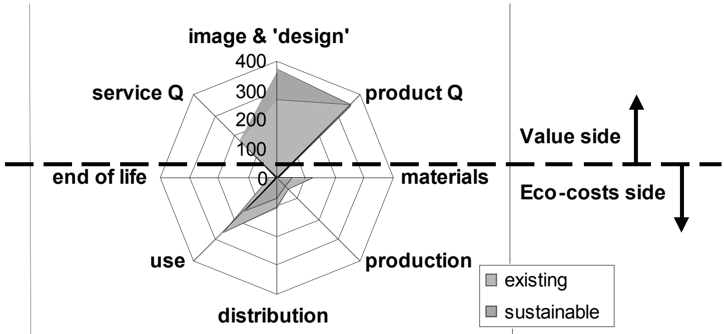


Figure E. The Eco-costs & Value Wheel (EV Wheel), with value and eco-costs (€).

Another powerful instrument to analyse a product is an eco-costs value chart of the manufacturing, assembly and distribution chain.
In the production chain, the value as well as the eco-costs gradually increase from the raw materials to the point of sales. This is depicted in the example of a 28" television in Figure F.
The EVR is also a good indicator of the sustainability of consumers expenditures. The so-called "rebound effect" is depicted in Figure G, showing that 'savings' are sometimes not a good solution for sustainability.
When eco-costs are reduced by 'savings', the economic value (costs for the consumer) is reduced as well, so the consumer will spend the money somewhere else. In the example of product 1 of Figure G, the net result is positive, since the money which is saved, is spent on another product with a lower EVR. In the example of product 2 of Figure G, however, the net result is negative, since the saved money is spent on a

product with a higher EVR.

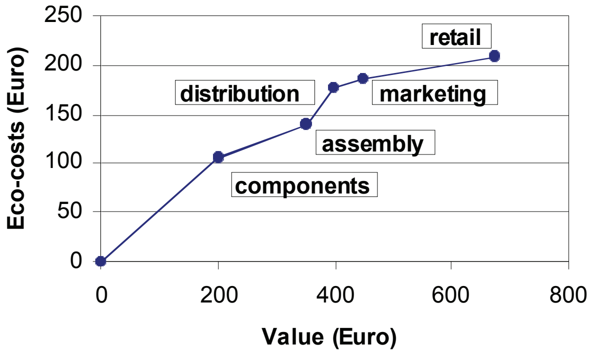


Figure F. The value and the eco-costs cumulative along the production and distribution chain (data for a 28" television).

The conclusion is that "savings" are only positive for the environment when savings are achieved in areas with a high EVR (and spent in areas with a low EVR).

A typical example of the rebound effect is related to the efficiency increase of light bulbs: when consumers spend the saved energy on more light (e.g. in their gardens) or on electricity for other domestic appliances, it does not help much in terms of sustainability.

In general, however, one may conclude that savings on energy can have a positive effect in terms of sustainability, since the EVR of energy is relatively high in comparison with other expenditures.
Savings on luxury goods (generally a low EVR because of the high labour content, might be negative for the environment since the "rebound" might be in the area of more energy (in the form of travel).

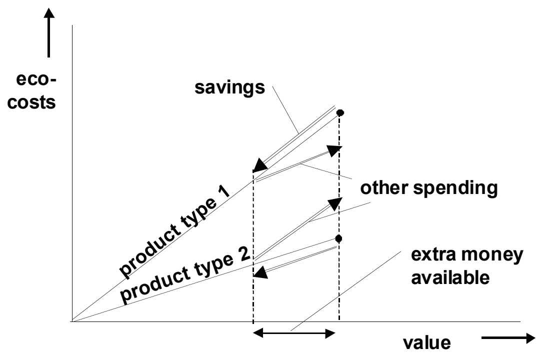


Figure G. The "rebound effect" of consumer expenditures.

(See Chapter 5)

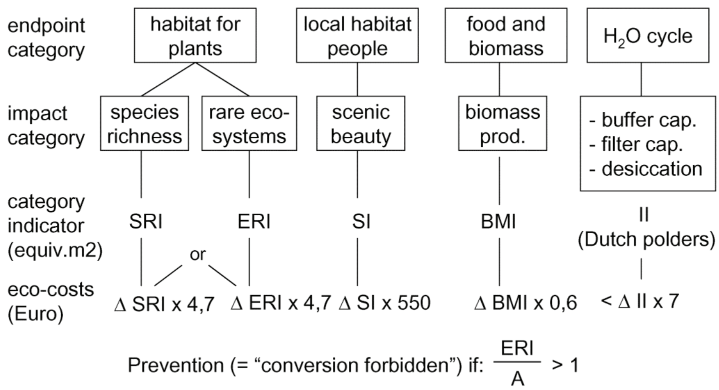
The eco-costs of land-use

Although it is argued that land-use in general cannot be integrated in the LCA of industrial mass products, a characterization system has been developed for conversion of land, since it is an indispensible element in special cases, such as:

1 LCAs of one-off products like buildings, roads etc.
2 rural and urban planning, to determine the best option and to assess possibilities of compensation (e.g. in the Dutch MER system).
3 For the eco-costs of tropical hardwood in LCA (taking into account the loss of biodiversity in tropical rain forests).

The calculation system for the eco-costs of land conversion is summarized in Figure I. The characterisation factors for species richness (as an indicator for loss of biodiversity) are use in practice, since the required data are known all over the world. For The Netherlands it is better to apply the available data for rare eco-systems.

Figure I. Characterization system for land conversion, and the corresponding eco-costs.



(See Chapter 6)

Communication

It has been tested whether or not the EVR model leads to a good understanding of the eco-efficiency of a product-service combination. In an experiment, 3 separate groups of 8-11 people were asked to rank four alternative solutions of a product-service system (the after sales service and the maintenance service of an induction plate cooker) in terms of sustainability. The 3 respective groups were:

1 customers (among whom representatives of consumer organizations)
2 business representatives from the manufacturing company of the induction plate cookers
3 governmental representatives (employees of the Dutch ministries of environmental

affairs and economic affairs, and of the Dutch provinces as well as consultants involved in governmental policies), all experts in the field of sustainability.

The instruction was to rank the proposed alternatives in terms of 'best sustainability ' as well as in terms of 'best choice in general', and to give arguments for the chosen answers. Furthermore it was asked what information was missing to make 'the right' decision on the ranking (as it was perceived by the participants).
At the end it was asked whether the eco-costs and the EVR were perceived as good criteria on which to base decisions.

From the experiments it can be concluded that:
1 The concept of Eco-costs was accepted by the majority of the non-experts, in preference to LCA output on which to base their ranking
2 The concept of the EVR was understood by the majority of the non-experts, but the consequences of it in terms of life style were not easily accepted (in particular the consumers group rejected the idea to judge on their life style by an eco-efficiency parameter)
3 The environmental experts in the governmental group did not directly accept the concept of eco-costs model (they wanted in-depth information first); they tended to stick to their existing knowledge of LCA data, which is in line with Rogers' theory of diffusion of innovation.

The experiment indicates further that:
1 the aspect of sustainability plays hardly any role in the decision when a consumer has a strong preference (based on other aspects, like the cost/benefit ratio) for a certain product type
2 however the aspect of sustainability can play a quite important role in the decision when there is no preference on other grounds.

This way of selection of products and services is depicted in Figure J

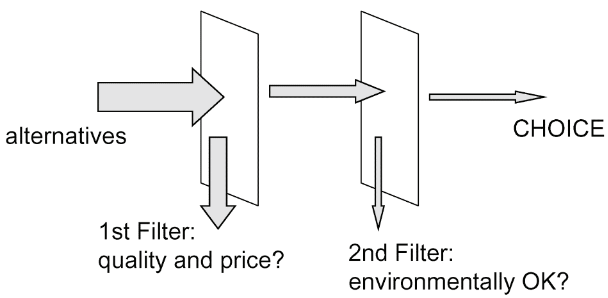


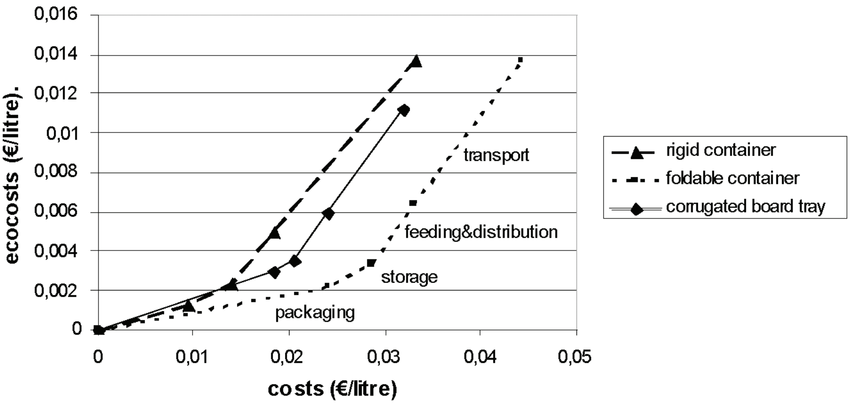
Figure J. The Double Filter Model : environmental data serve only as a second order filter in the decision of consumers

(See Chapter 7)

Case: the transport function

To illustrate the advantage of the EVR model in cases where service plays an important role, a transport chain has been analysed: vegetables from the Dutch greenhouse to the retail shops in Frankfurt. The chain has been analysed for three transport packaging systems: 'one way' solid board boxes, returnable foldable cratesand (20 round trips) returnable rigid crates (30 round trips). See Figure H.

Figure H. Costs and eco-costs per litre net transport volume for the total chain (total distance 500 km); price levels 2004.



For the design of transport systems, an integral LCA approach of the total transport chain (cycle) is required to minimize eco-costs. This is because of the high interaction of the system components: the packaging system, the transport system and the storage system.
Efficient use of volume (of the truck as well as of the transport packaging) plays a key role as well as the re-use of packaging materials.
The eco-costs for the solid board box system appeares to be lower for distances lower than 200 km, especially when the truck can be used for other freight on the return trip. Costs are lower at distances more than 500 km So there is no reason from the environmental perspective to prefer plastic re-usable crates, which is an embarrassing conclusion in the light of the discussions in The Netherlands that started in the early nineties: 'durable' does not go hand in hand with 'sustainable' in this case, because the use of energy appears to be rather dominant in those transport systems.
(See Chapter 8)

Cases: Recycling of building materials

The environment is an important subject in the construction sector. This is why the following for cases have been further analysed, using the EVR model:

- What is the environmental advantage in replacing gravel in concrete with concrete aggregate?

- Can the required sand extraction on land be replaced with sand extraction at sea?
- From an environmental point of view, is it better to use mixed aggregate in concrete than in roads?
- What is the environmental advantage of a mobile crusher as opposed to a static crusher?

Analysis of this leads us to the following conclusions regarding the environment:
1. The advantage of using concrete aggregate (rather than gravel) for concrete lies primarily in the reduced amount of material dumped. Differences in emission levels are negligible
2. From an environmental point of view, sand extraction at sea is not preferable to sand extraction on land
3. Although two totally different systems are used, in the end there is little difference between using concrete aggregate in concrete and using mixed aggregate in roads.
4. From environmental point of view, a mobile crusher is preferable to a static crusher.

(See Chapter 9)

The road towards sustainability

The combined approach of eco-costs and value reveals new opportunities to reach at least "factor 4" in eco-efficiency. The required transformation, however, is far from easy.
In order to describe the mechanism of the required transition, the 'three-stakeholders model' has been introduced. See Figure K. This model provides the main interactions between business, government and consumers/citizens with regard to the issue of sustainability:
- citizens ask the government to care for their long term interest and to create sustainability
- the government defines restrictive rules and has to create an even playing field for the industry
- the industry satisfies short term consumer needs in terms of maximum value for money.

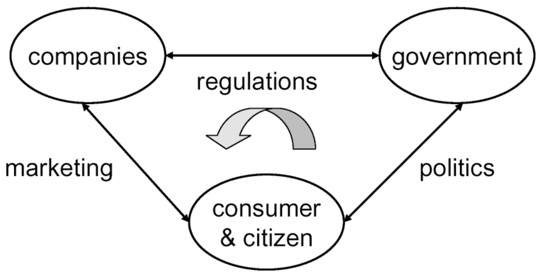


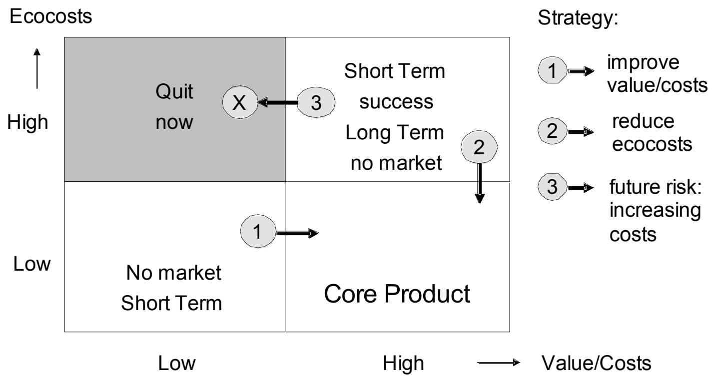
Figure K. The 'three-stakeholders model' and their main interactions.

With regard to the introduction of green products, the EVR model reveals two important issues:

1 in the product portfolio management strategy, companies have to enhance the EVR of products with a high value/costs ratio (rather than try to enhance their cost/value ratio of products with a low level of eco-costs, as many environmentalists propose). See Figure L.

2 marketing strategies need to be differentiated:
  - for commodity products (products where it is hard to differentiate on price/value) the low eco-costs of a product create a competitive edge, but keep the price/valueatthesamelevel
  - make the eco-costs part of the image for special products and high quality products, but do not stress the sustainability issues too much, since consumers go for the best price/value.

Figure L. Product portfolio matrix for product strategy of companies.



It is shown why it is so difficult for governments to force the industry in the direction of sustainability, and keep an even competitive playing field at the same time. Gradually increasing tax on pollution would work in a closed economy, but has the adverse effect of 'exporting environmental pollution' in an open, global, trade.

Tradable Emission Rights systems for the industry, in which the government takes part, seem to be the most promising solution at national level.

On global level a Tradable Emission Rights system between governments might become the right tool to freeze the CO_2 emissions at its current level. Drastic and fast reduction of the emissions, however, cannot be expected from such a system. The goal can only be reached step by step.

Systems of subsidies (or tax relief) on consumer products are suitable to facilitate the market introductions of innovative products, but only in market niches, and only for products with a high EVR. General subsidies (or tax relief) for other than these products have to be avoided.

(See Appendices)