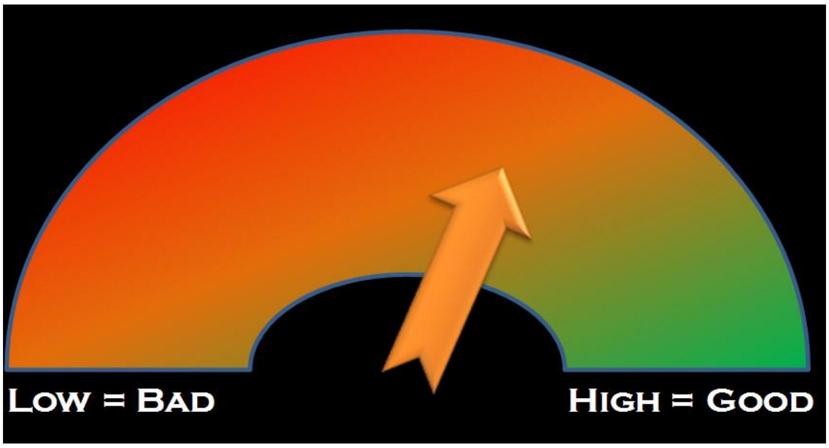
CHALMERS



Eco-Efficiency

The conceptual model, the concept model and an operational data structure

RAUL CARLSON

eco2win AB for
CPM – Center for Environmental Assessment of Product and Material Systems
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2009

CPM Report No. 2009:2

1. INTRODUCTION

1.1 Non-technical introduction

Eco-efficiency is a concept that combines business concerns (economy) and environmental concerns (ecology). This combined concept intends to acknowledge businesses' need to grow and develop, while at the same time acknowledging the fact that this growth and development historically has been profoundly unsustainable, based on irreversible exploitation of all possible dimensions of Earth's natural environment. Eco-efficiency is a tool designed to measure while good businesses develop with continuously lesser environmental impact.

The less harm that is done, the higher the eco-efficiency value. The more that is done without increasing the environmental impact, the higher the eco-efficiency value. In short, *the higher the eco-efficiency, the better*.

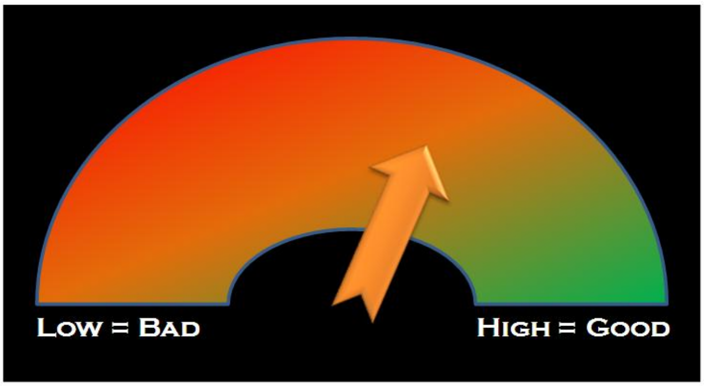


Figure 1. The higher the eco-efficiency, the better.

The eco-efficiency concept acknowledges that one gets nothing if one spends nothing. We need resources to construct, eat and shelter. We change the environment to live, transport and reject our waste. We increasingly compete with other life on Earth as we successfully outlive dangers, diseases and starvation. Eco-efficiency means that we should be more efficient when we satisfy our needs. The eco-efficiency tag-line is "To do more with less".

Figure 2. Eco-efficiency means to do more with less.

1.2 Technical introduction

Eco-efficiency is a wide concept designed to drive the decoupling of economic growth from environmental deterioration. The purpose of this report is to present a detailed model of eco-efficiency as a management decision support tool; eco-efficiency as a tool to guide decisions, measure progress and communicate priorities and results. This means that this report presents a model of the essential information contained in the concept of eco-efficiency.

To meaningfully construct such a model of the information, this report strives to describe eco-efficiency as a clearly defined concept, with a clearly defined structure of distinguishable sub-concepts, with logic relationship between these sub-concepts and with unambiguous information and data items. Hence, this is a technical report. The technical exactness does not span the full width of eco-efficiency and does not claim to exactly match a current consensus on eco-efficiency data and information. In fact, there is not yet such a consensus in this field. But one of the purposes of this report is to provide guidance during the development of an international standardization of eco-efficiency within ISO. The work is performed under ISO/ TC 207/ SC 5 and the resulting document is intended to be coded ISO 14046.

During the authoring of the report much effort has been given to transparently state relevant and significant assumptions and limitations concerning the nature and logic of the concept and the sub-concepts of eco-efficiency. This is done not as an attempt to enforce how eco-efficiency is to be understood, interpreted and applied, but to facilitate for readers to make their own judgments about whether they agree with the statements or not. The transparent documentation is intended to support a development of a consensus about eco-efficiency information by stimulating the readers' awareness of agreement or disagreement and to invite to points for discussion.

The report presents this detailed model at 4 different levels, with consecutively increasing level of detail:

- **Eco-efficiency conceptually**: an informal description of the meaning and the intentions of eco-efficiency, and describes how eco-efficiency is applied, presented and interpreted.
- **The concepts of eco-efficiency**: a formal description of the concepts of eco-efficiency and their semantic, functional and logic relations.
- **The information of eco-efficiency**: a general overview of the information needed to calculate and present an eco-efficiency value.
- **The data of eco-efficiency**: a detailed overview of each individual data item needed to calculate an eco-efficiency value.

Figure 3 shows the relations between these four consecutive chapters. Each chapter describes a more detailed view of eco-efficiency, hence also dissolving the contextual semantics (meaningfulness) provided by the first conceptual overview.

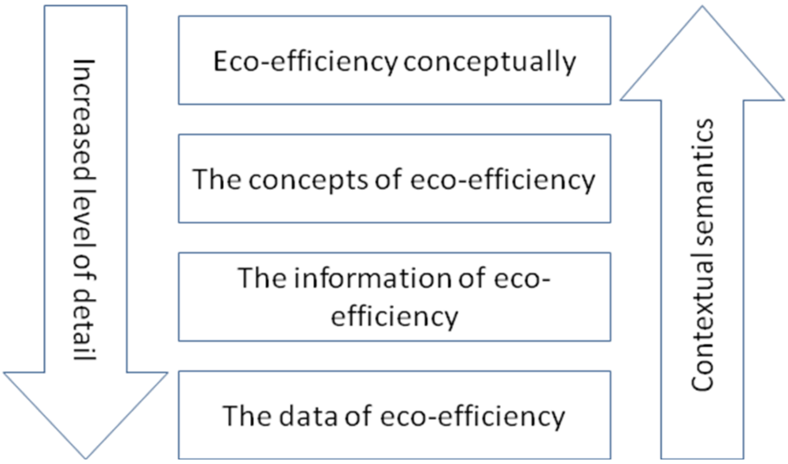


Figure 3. Reading guide for the report. It shows how the level of detail increases throughout the report, and how the initial chapters bind the model to the contextual semantics of eco-efficiency.

The conceptual models, concept model and data structures presented in this report is produced from the ecological and engineering sciences perspective. For example, therefore there is a difference between the data structures for identifying the gain valuation of a product and the cost valuation of the same product. From the perspective of ecology and engineering sciences the costs of a product is modeled and valued by applying complex scientific cause-effect methodologies, while from the perspective of these natural and technical sciences the gain values of the same product are most often acquired by less transparent or analytical methods. This does not mean that we believe that the actual valuation of gains should be any less advanced than the valuation of costs. It is merely an expression of available toolboxes. We welcome a more advanced modeling of gain valuation in an update of this concept model, should anyone show such models.

2. ECO-EFFICIENCY CONCEPTUALLY

2.1 Direction

Eco-efficiency supplies management with data about which direction to advance business decisions. Eco-efficiency aids management to decouple a positive economical progress of the organization from a consequential regression of the environment.
Eco-efficiency is calculated as a cost-benefit analysis (CBA) with the specific context of management for sustainable development.

Figures 4 and 5 exemplify two rather different views of a tool which supports when choosing direction.

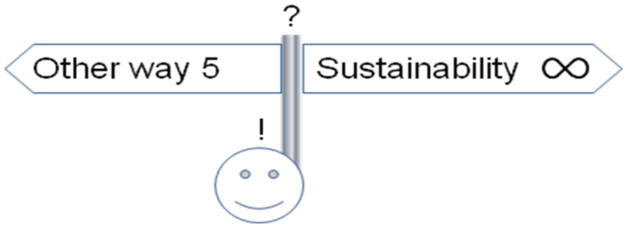


Figure 4. Eco-efficiency is a road-sign pointing towards sustainability.

Eco-efficiency may be a tool that helps to clearly distinguish between different choices, such as different design alternatives, strategic business development strategies or policies.

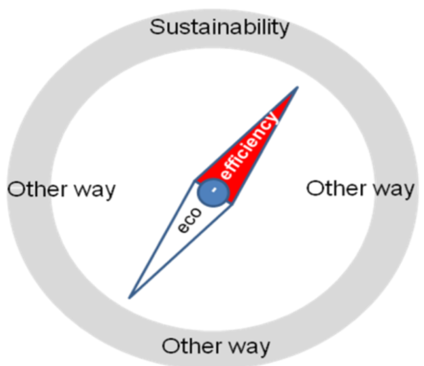


Figure 5. Eco-efficiency is a compass that indicates how much the current direction deviates from the straight route.

Eco-efficiency may be a tool that is used continuously in a business or other organization in any daily operative situation, such as to follow up detailed design choices, as an aspect in any economic reports from the different departments, as an indicator on transportation statistics, etc.

2.2 Relevant

Eco-efficiency describes the ratio between the relevant gains and the relevant costs when organizations and systems of the industrial society provide goods or services.
The scope of relevance for eco-efficiency is arbitrary, and may range from highly detailed decisions concerning product design and individual purchases, to organisational goal-setting, performance measurement and management, to strategic and political road maps and agendas.

2.3 Relative

Eco-efficiency is a relative concept, describing the relationship between a gain and the cost for providing that gain. Eco-efficiency is also relative in the same sense as it is directional, i.e. it provides a positional relative value between two versions of a product or a function. Without a defined point of reference an eco-efficiency is useless, hence an eco-efficiency is always relative. This is equally try for qualitative as for quantitative eco-efficiency values.

2.4 Quantitative to measure progress

Eco-efficiency is a concept to define a continuous quest for an organization, i.e. to continuously strive to 'do more for less'. This quest can be formulated both qualitatively and quantitatively depending on purpose or situation. The model presented in this report is developed regardless of a qualitative or quantitative view of eco-efficiency. However, the quantitative view is more intuitive and simpler to describe, and also provides a tool to measure consecutive or relative progress towards eco-efficiency. Therefore, from here on, the quantitative view of eco-efficiency will be the consistently held throughout the report. When found necessary and relevant this view is contrasted to the qualitative view as a discussion.
Quantitative eco-efficiency provides a quantitative measure of the magnitude of the relation between costs and gains. This is done by firstly providing quantitative measures of the costs and the gains, and by dividing gains by costs:

Eco-efficiency = gains/costs

Formula 1. Eco-efficiency expressed as a ratio.

Both gains and costs may be quantified using any arbitrarily chosen unit, but it is common to use a monetary unit, like € (Europe), $ (USA or globally) or ¥ (Japan).
Quantification of gains is commonly described as price or market value, while it is often less straightforward and more debatable to quantify costs.
Figure 6 exemplifies different ways to value the gain from the production of a product.

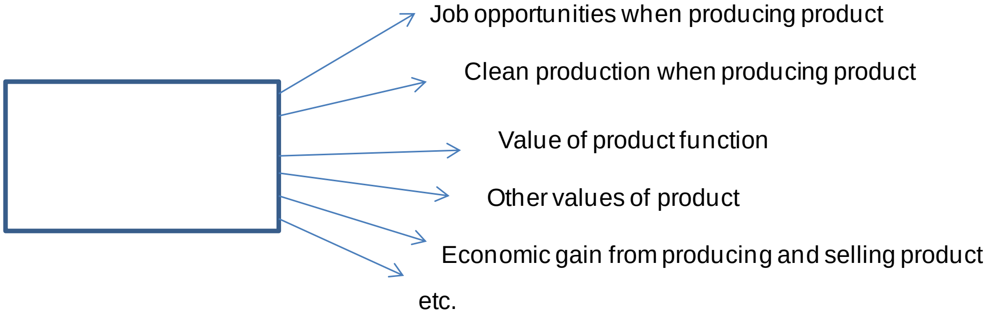


Figure 6. Different gains from the production of a product.

Figures 6 contains an example of a gain that may be questionable with regards to what is included with eco-efficiency and what is not. One commonly held view of eco-efficiency is that it relates economy with environment, but not with for example social issues. Job opportunities, however, is a social issue and may or may not be included as a gain of a product.

Figure 7 exemplifies different ways to value costs for producing a product.

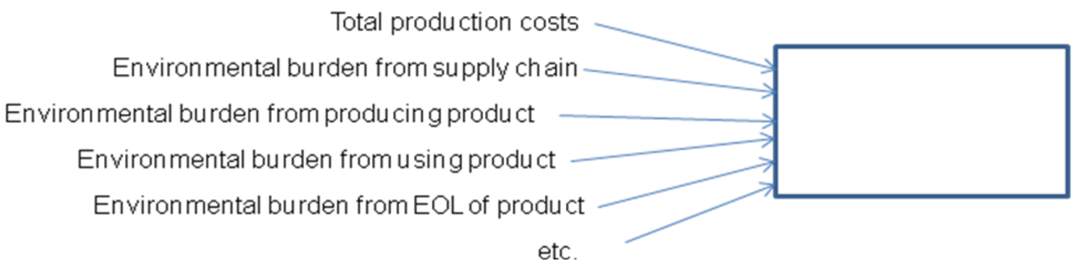


Figure 7. Different costs from producing a product.

2.5 Subjective

Eco-efficiency is a subjective concept, in which both costs and gains are constructed from subjectively selected value-items. Figure 8 picture this by explicitly showing that there are large domains of potential cost and gains, but that the actually included costs and gains is a smaller selection of issues from this large potential domain.

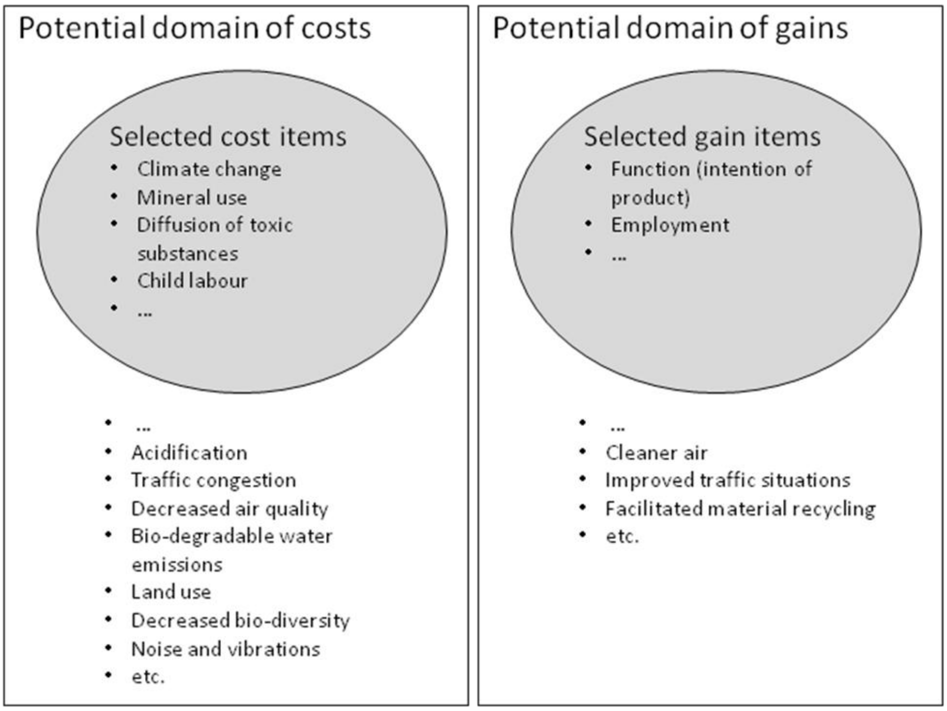


Figure 8. Eco-efficiency costs and gains are based on subjective selections.

For eco-efficiency to be a meaningful tool for communication and comparison it is necessary that the actual choice of costs and gains are transparently communicated and explained to the intended audience.

2.6 Flexible

Eco-efficiency is applicable to evaluate any good or service provided in the industrial society. It is also applicable to any cost or any gain, or even to any aggregate of costs or aggregate of gains.

Figure 9 provides a means to explain that costs can increase either by increased impacts on each *Selected cost items*, such as climate change, mineral use, diffusion of toxic substances or child labor. Figure 8 also makes it understandable that the gain can increase by a higher value of any of the *Selected gain items*. But from figure 8 one can also derive that costs and gains can be increased or decreased by changing which cost or gain items to select. Hence, eco-efficiency is very flexible and it is important to hold in mind which costs and gains to include in an actual instance of an eco-efficiency measure.

2.7 Encompassing

Eco-efficiency encompasses both internal and external costs and gains of a certain product or function. The system boundary decisions are the same as in Life cycle assessment according to ISO 14040 and ISO 14044.

3. THE CONCEPTS OF ECO-EFFICIENCY

3.1 The gain, or the value of function

The gain from any industrial organization or system is appreciated by a set of value-setters. For example, there are many different ways to value the production of a certain product. Figure 9 below exemplify valuation of a product.

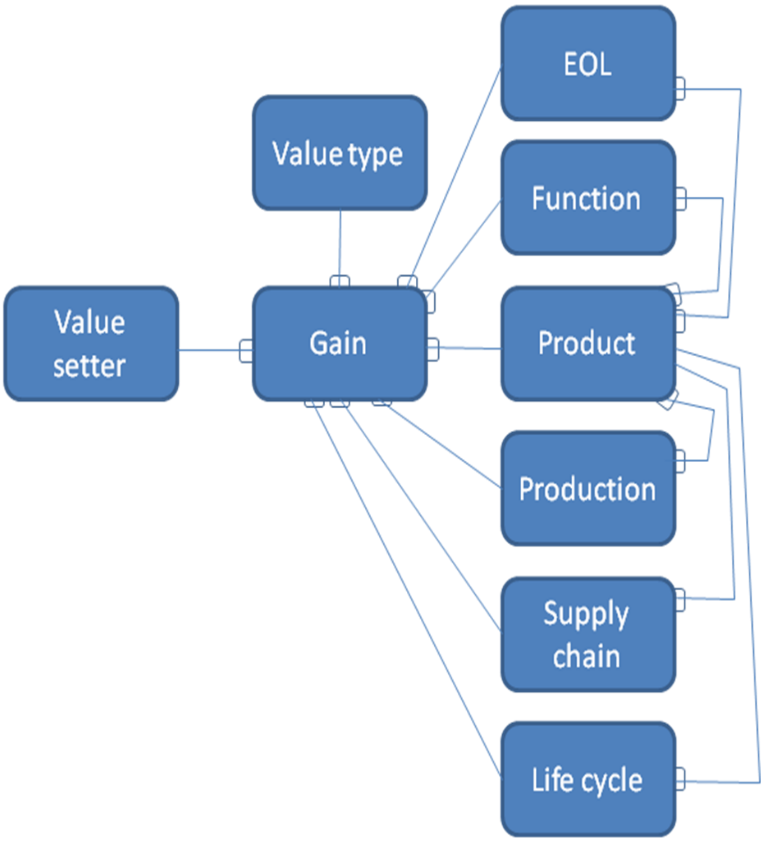


Figure 9. The figure describes the general concepts needed to describe the value the gain of a product.

By generalizing EOL, Production, Supply chain and Life cycle as ‘Process’, figure 10 below describe a less complex model for valuing a product. The generalization describes that a product can be valued with regards to its function, with regards to ‘itself’ and with regards to the processes associated with any part of its life cycle.

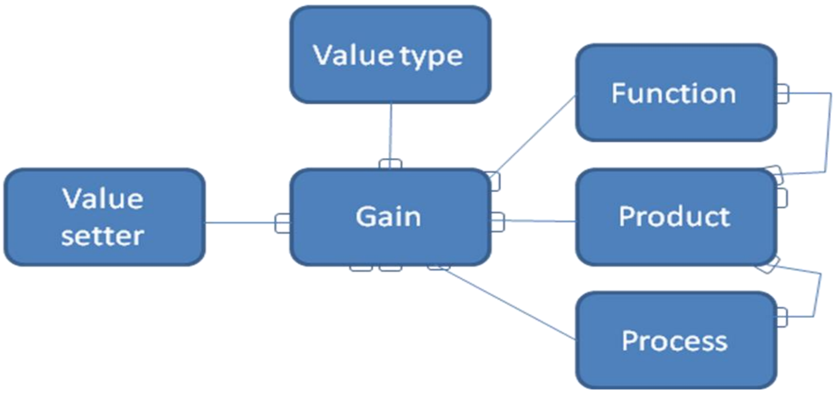


Figure 10. Gain of a product can be valued with regards to its function, with regards to 'itself' and with regards to the processes associated with any part of its life cycle.

3.2 The costs, internal and external costs

The cost from any industrial organization or system is appreciated by a set of value-setters. Some costs are already included with the cost for producing the goods or services, the so called internalized costs. Other costs are not yet internalized, hence not part of the production costs, but are anyway selected as costs. These are called external costs.

Figure 11 below exemplify how to assess the cost of a product. The figure shows that a product can itself have a cost, have a cost with regards to its usage, its supply chain etc.

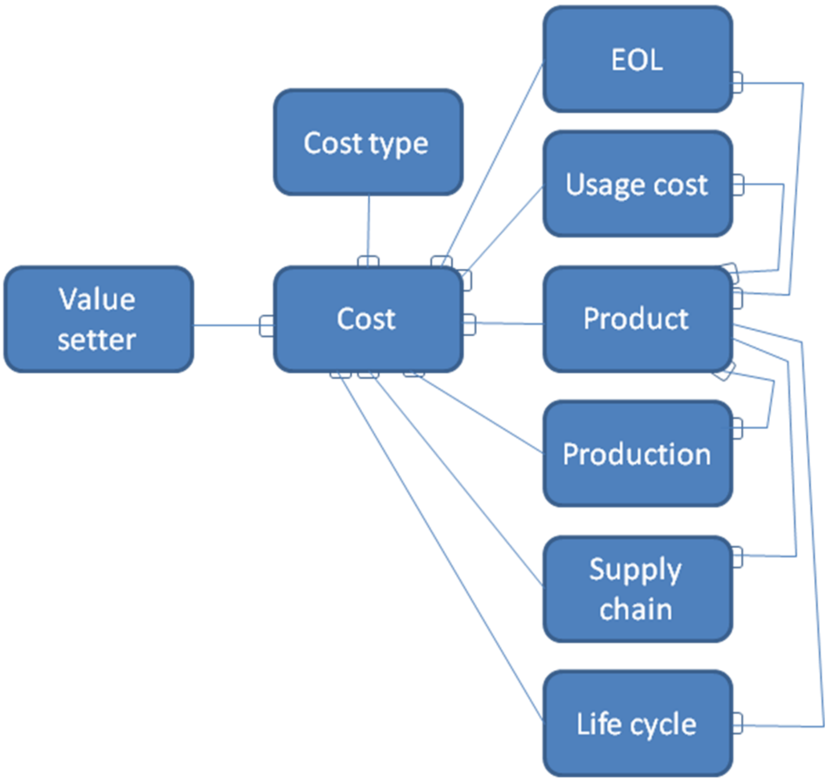


Figure 11. The figure describes general concepts needed to describe the cost of a product.

By generalizing EOL, Production, Supply chain and Life cycle as 'Process', figure 12 below describe a less complex model for valuing a product. The generalization describes that the cost of a product can be associated with its usage, the purchase of the product or with a processes associated with any part of its life cycle.

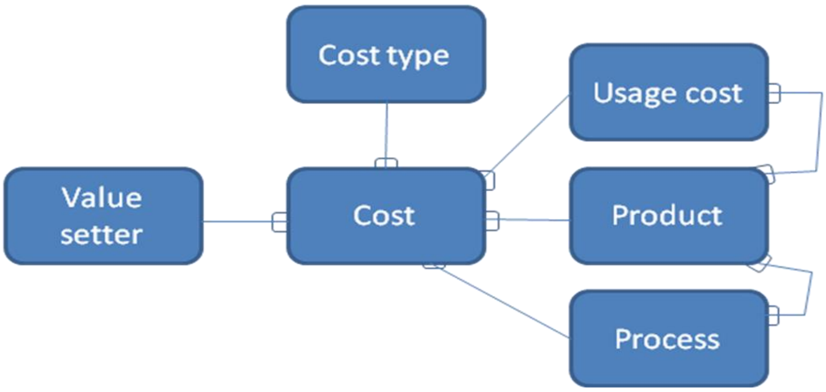


Figure 12. A product can be valued with regards to its function, with regards to 'itself' and with regards to the processes associated with any part of its life cycle.

3.3 Setting values on costs and gains

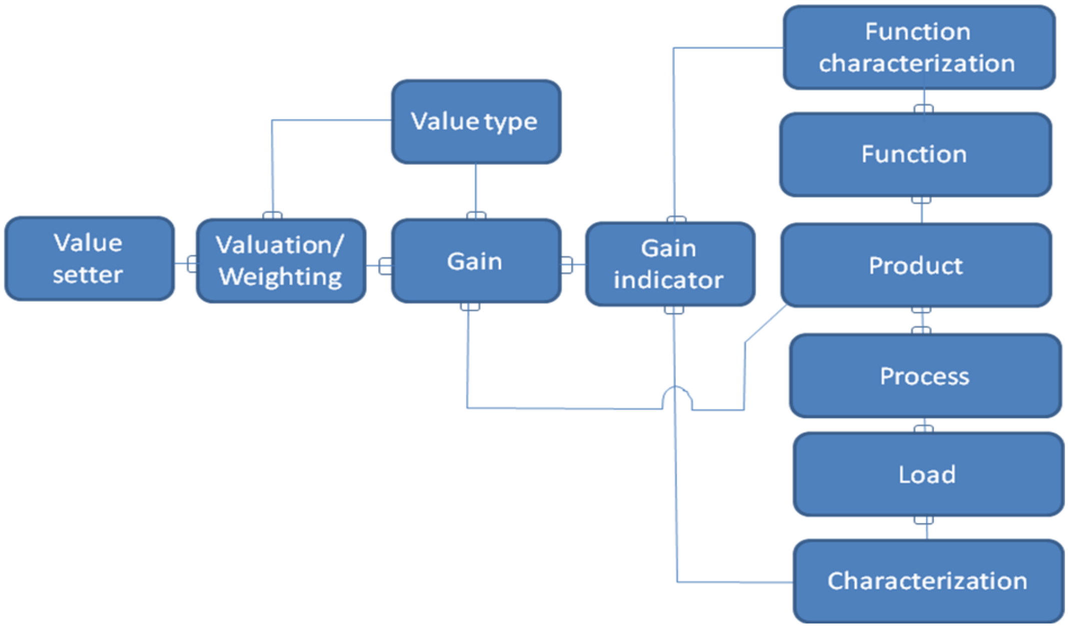


Figure 13. Valuation of gain with increased detail of concepts.

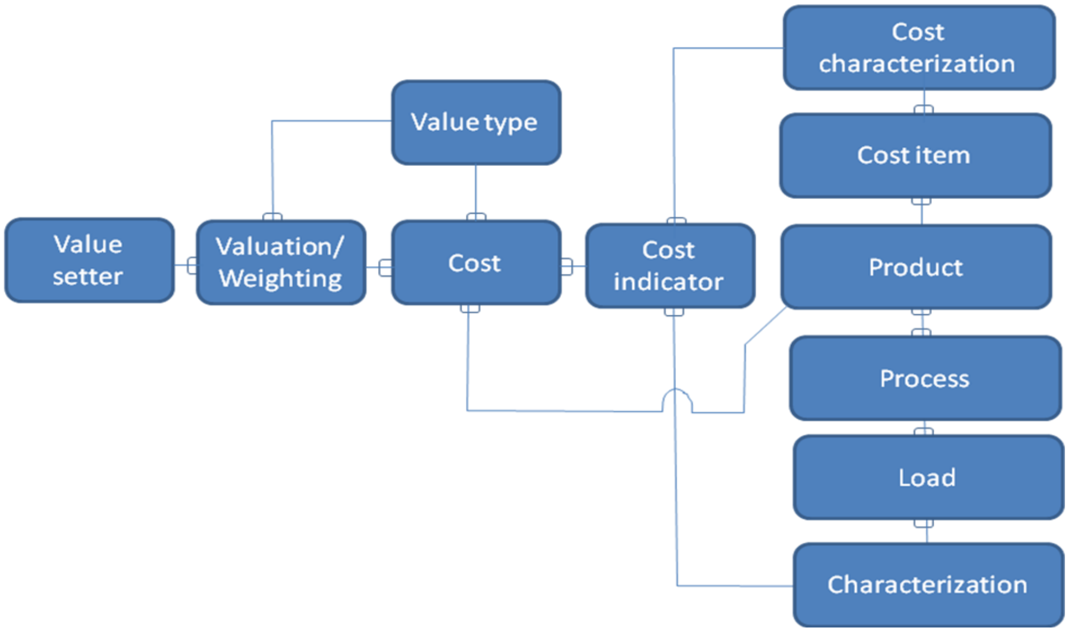


Figure 14. Valuation of costs with increased detail of concepts.

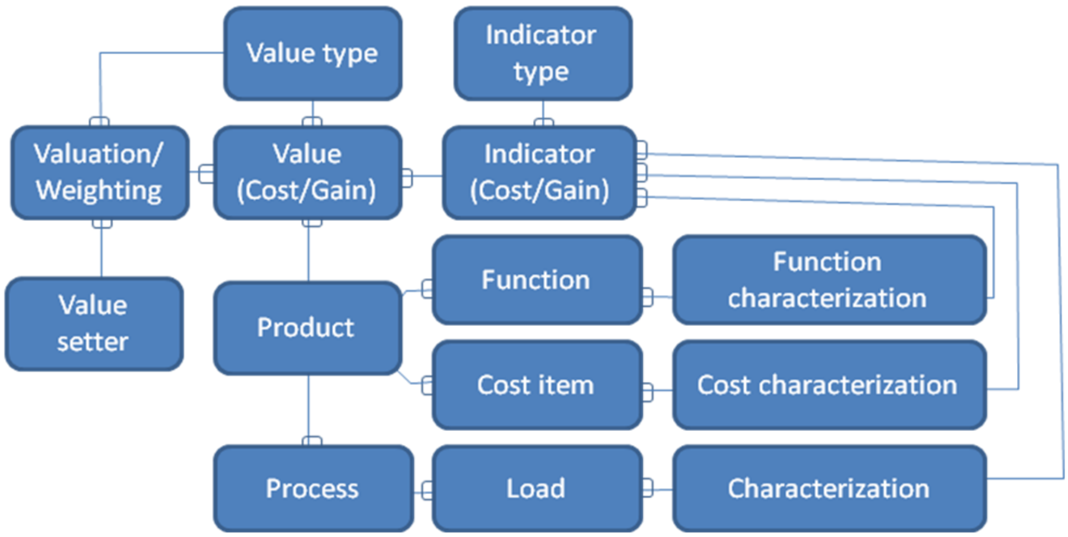


Figure 15 Combined model of the concepts that describes the costs and the gains of a product.

3.4 Eco-efficiency; a compass to sustainable development

Eco-efficiency provides data about the direction towards sustainable development. Direction is a relative concept; hence any single eco-efficiency value needs to be related to some interpretation-value which tells what to do and where to go.

The ratio between gains and costs may be used to indicate the eco-efficiency of the results of a next decision, but in order to interpret such a quantitative value in terms of improved or worse sustainable development, it is necessary also to know the current eco-efficiency. Hence, in practice the concept of eco-efficiency is relative not only with regards to the ration between costs and gains, but also with regards to that a single eco-efficiency ratio cannot communicate environmental performance.

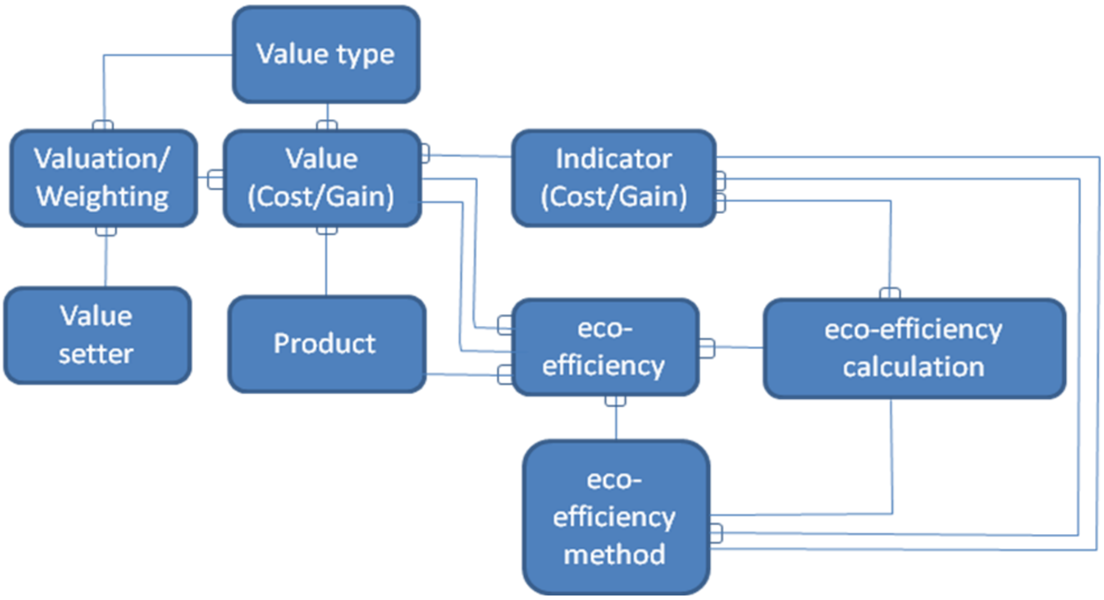


Figure 16 Eco-efficiency is a combination of a selected set of values concerning a specific product.

Figure 16 show the full concept model describing eco-efficiency.

4. THE INFORMATION OF ECO-EFFICIENCY

4.1 The gain, or the value of function

The information needed to describe the value of a function, may range from the actual purchase price to a more general and political price setting.
The concept model presented in the figures in section 2.1 suggests that at least the following information should be given to fully the describe the gain, or the value of the product and its functions:

- Product
- Function(s)
- Process (Product system)
- Value setter
- Value type
- Gain (Value)
- Valuation/Weighting

To achieve transparent information it is also necessary to provide a list of product-independent Gain indicators to which the value of the function may be characterized through a Function Characterization. This is in symmetry with how environmental loads are characterized onto category indicators in the LCA methodology.

4.1.1 Product

It is obvious that the product for which a certain value or gain is assigned need to be unambiguously identified. Depending on situation, the needed information is different. In a product development project it may be necessary to distinguish between current and different future versions of the product, while at the market it may be enough to distinguish between different brands and models, or between different process batches. The identity needs to be sufficiently described to provide enough support to decisions makers.

4.1.2 Function(s)

As described in section 2.5 eco-efficiency is based on choices of which values or gains to take into consideration. These choices can be more or less made on rational or scientific grounds or more or less subjective. This is partly based on the fact that a product can have many different functions, some which are implicit rather than explicit, and some might not even have been part of the initial design. For example, a wrist watch does not only tell time, but may also work to signal the economic status of the wearer of the watch. Another example is packaging materials which protects goods during transports, are designed to draw attention in shops and function as fuel in waste incineration power plants.

It is important that each intended and valued function is clearly described to give the full key to the full value or gain of a product.

4.1.3 Process (Product system)

When considering the value or gain of a product this may be done at any scope of the product life cycle. One may consider only the product itself, or one may consider also the gains or values when producing the product. One may for example consider whether the production is done using best available, efficient and clean technology, or with old technology with low efficiency and high amounts of emissions. One may consider whether the components and raw material is produced in environmentally friendly ways, and one may consider whether the product allows for an environmentally friendly end-of-life treatment. Food, for example, may be viewed only with regards to its nutritional properties, or also with regards to how it has been farmed and cropped, how it has been transported, with regards to risk for toxic remains in vegetables, fruits or meat, or with regards to how waste is taken care of. It is important to inform about which such considerations has been taken. It is also recommended that such considerations have been made consistently, preferably by using the ISO 14040-standards methodology.

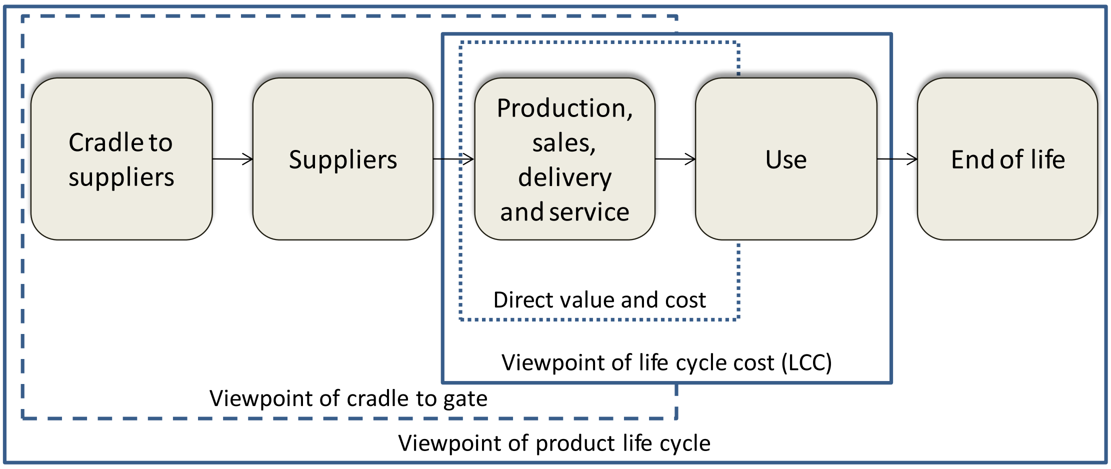


Figure 17. A product system may be viewed in many partial ways, such as the normal direct value and cost, the viewpoint of product life cycle cost (LCC), the viewpoint of cradle to gate or the viewpoint of a full life cycle. The full gain or value is different depending on choice of viewpoint.

Figures 17 describes values or gains can be related to product systems in different ways. To facilitate comparability a description of the scope should be produced.

4.1.4 Value setter

Different functions of a product may be valued in different ways by different people or groups of people. It is for example likely that the buyers and users of a product give a different value to the functions of the product than those that are not interested buyers.

4.1.5 Value type

The actual gain (or value) may be provided as a single numerical value with some unit, assumably monetary. But is is also possible that a number of values may be given, to describe for example one not aggregated value for each function. It is also possible to describe the gain or value in not numerical terms, such as in a qualitative description, as a category of a range of categories (e.g. good, acceptable, not acceptable) or as logic values (e.g. yes, no).

4.1.6 Gain (Value)

The gain or value, a numerical or qualitative value in accordance with 4.1.5. Value type.

4.1.7 Valuation/Weighting

There may be many different ways to value a certain function. Functions are commonly valued with some market price, but market prices fluctuate depending on season, trends, market competition, etc. Valuation and weighting can also be made by questionnaires and by expert panels. There are many different ways to value and weight different functions. It is therefore important to supply information about how the valuation or weighting has been performed.

4.2The costs, internal and external costs

The information needed to describe the cost, i.e. the internal and external costs may range from the actual purchase price for component and material, to the external costs for direct emissions, and advanced LCA models to assess the external costs both up- and downstream from the production site.
The concept model presented in the figures in section 2.2 suggests that at least the following information should be given to fully the describe the cost of a product:

- Product
- Function(s)
- Product system (Process)
- Value setter
- Value type
- Cost

In symmetry with information needs for gains it is also necessary with Cost indicator and Cost characterization. The latter is assumed mostly to be equal to 1, but this might not always be the case.

4.2.1 Product, Function(s), Product system (Process)

The product, the function and the product system is exactly the same for the costs of a product (section 4.1) as for the gains and values (this section 4.2). In practice this most often 'boils down to' that the gains and values are expressed as the economic value of the product or function, and that the costs are the environmental life cycle costs of the product system. But in order to give a truly balanced view, also upstream and downstream gains and values should be taken into account, as well as all both direct and indirect life cycle costs of the product. The modeling of a consistent product system that makes costs and gains both comparable and calculable is a key difficulty when calculating eco-efficiency.

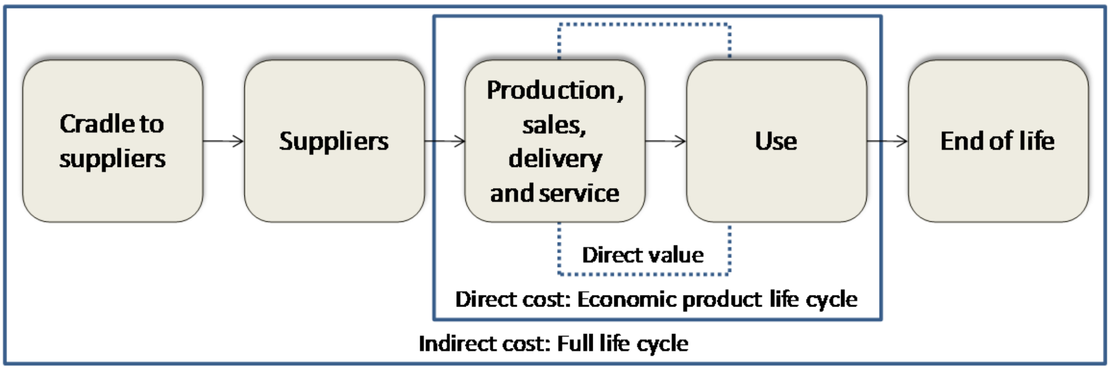


Figure 18. The picture describes a situation where the direct value (gain) of the product system is the strict market value, e.g. the price. The cost is described as a combination of the full direct life cycle cost and the full environmental life cycle cost. Hence, the gains and costs have different scopes.

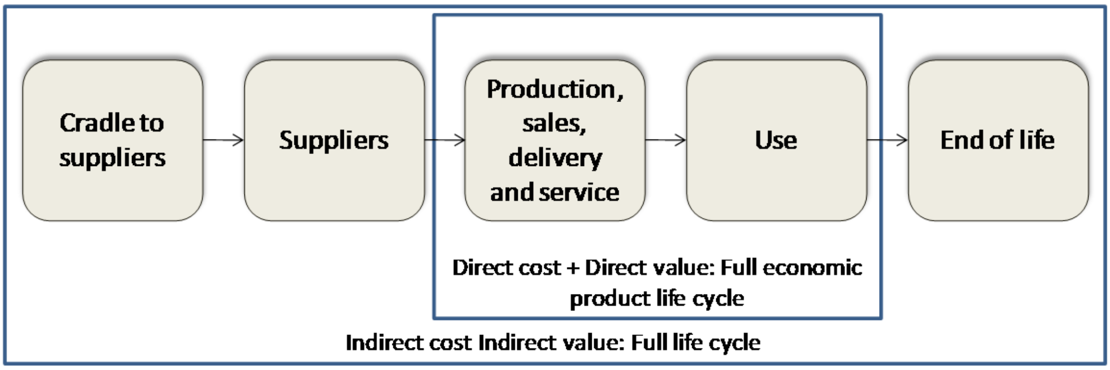


Figure 19. The picture describes a situation where both the direct cost and the direct value, and the indirect cost and the indirect value have the same product system scope.

Figures 18 and 19 describe how values (or gains) and costs can be related to product systems in different ways, leading to incomparable data. To facilitate comparability a description of the scope for costs should be produced.

4.2.2 Value setter

The persons or demographic groups responsible for evaluating the directs costs of a product are generally the same as those valuating the direct gains. Those people are generally interested in the product and its intended functions, in the roles of producers, buyers or users. It is likely that the people or demographic groups that value the indirect costs are other people, not interested in the product as such. Examples may be citizens that live as neighbors to production plants and transport routes, experts in ecology and environmental mechanisms, non-governmental policy setters, etc. Different value setters are likely to address different costs, and are also likely to assign different values to different cost items (compare with section 2.5).

4.2.3 Value type

Costs can be expressed as numerical values or as qualitative explanations as well as categories (e.g. social, environmental, economic) or as logic values (e.g. yes, no)

4.2.4 Cost

The cost is a numerical, qualitative, categorical or logic value.

4.3 Efficiency, the compass

The information needed to meaningfully express an eco-efficiency value is (as stated already above) reference or baseline values, but it is also necessary to provide information about scope, i.e. to identify the point in the economical/ecological sustainability space where the actual linearization is valid, as well as a statement that describes why the linearization is valid.

The information needed to unambiguously determine the concepts presented in section 2.4 are:
Eco-efficiency and eco-efficiency calculation, which together denote the value of an eco-efficiency indicator. The eco-efficiency method describe in detail the meaning of the value, the meaning of the selected indicators that are aggregated into the eco-efficiency value, recommended presentation of the value and the mathematical calculations.

4.3.1 Reference/Baseline value

Whether the eco-efficiency is expressed in numerical terms or in qualitative values, or in any other way, it is necessary to relate the efficiency value to some reference point or base value. In general it is important to supply the reference value or baseline both with a range (from e.g. 'worst today to best available', or 'previous version to sustainable version of product' etc.) and a scale (e.g. 'we plan to exchange all production units into best available within 3 years', or 'we intend that a sustainable version of the product is not attainable, but that we can reach a 90% sustainable product within 10 years'). Such information helps the reader of an eco-efficiency value to interpret the quality of both absolute values and improvements.

4.3.2 Scope of validity

Since an eco-efficiency value is based on a specific product or type of product, and on a specific product system, specific groups of value setters etc., its validity will have limitations based on these specifics. If a new version of the product is based on another technology, if the product system shifts depending on other choices of suppliers, or if new indirect costs are found to be important for the product, the eco-efficiency value may no longer be valid or meaningful

4.3.3 Efficiency

By providing the eco-efficiency value with a frame of range and scale of reference or baseline value, and by providing a description of the scope of validity for the efficiency value, the value may be communicated in any appropriate way. Depending on situation and the communication may allow for only a single quantitative value calculated from numerical values of costs and gains (figure 20), or the situation may allow for a combination of numerical values and numerical or qualitative discussions about uncertainties in the figures. Figure 21 is an example of how the eco-efficiency value may be communicated in a form that shows different stakeholders how their actions and interactions with the product and its life cycle will impact and change the eco-efficiency. The schematic summation in figure 22 exemplifies how the full eco-efficiency is the result of choices made by each different stakeholder.

$$\eta = \frac{\text{Gain}}{\text{Cost}}$$

Formula 2. In some situations the eco-efficiency value may be communicated as the numeric value of the ratio between gain and cost.

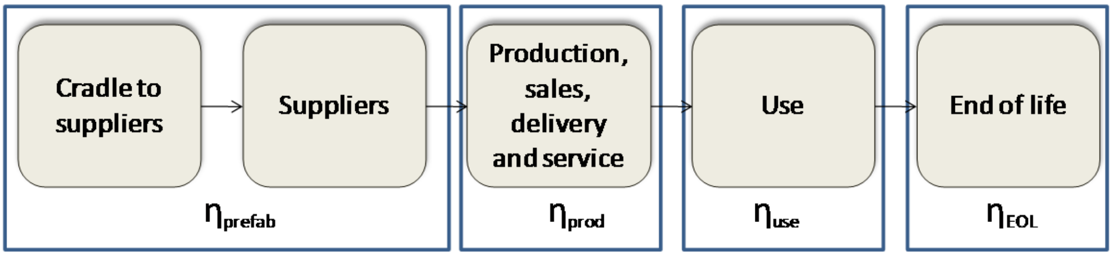


Figure 21. To communicate the significance of the different stakeholders throughout a product life cycle, it may be valuable to communicate different eco-efficiency values for different life cycle stages.

$$\eta_{tot} = \eta_{prefab} + \eta_{prod} + \eta_{use} + \eta_{EOL}$$

Formula 3. A full eco-efficiency may be summarized as a sum of the partial efficiency values for each life cycle step.

Figure 22 shows a picture based on the BASF-method graphical method for presenting eco-efficiency. It is intended to show a comparison between the eco-efficiency of two or more concepts. The actual choice of communication depends on the situation.

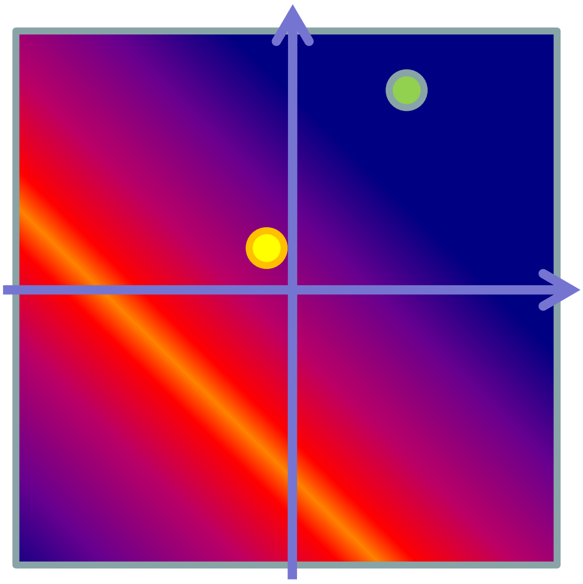


Figure 22. This picture shows the eco-efficiency presentation method, a two dimensional economic/environmental diagram, with positive environmental and economic values towards upper right, and negative environmental and economic values towards lower left.

5. THE DATA OF ECO-EFFICIENCY

The data needed to describe eco-efficiency will in the following be described in terms of detailed data fields and their relations. A combination of simple graphical schema representations and a simple form of data definition language will be used. It is intended that before an actual implementation of these data structures it should be decided whether to apply SQL, EXPRESS, XML etc.
It should be stressed that the model needed for transparent assessment of life cycle costing (LCC) and/or life cycle assessment (LCA) is not part of these models since such are available elsewhere such as in Carlson et al 1995, Carlson et 2000 and Carlson et al 2002.

5.1 The gain, or the value of function

Most commonly, the gain is expressed as a quantitative valuation of a product, such as its actual selling price or the life cycle cost that a customer considers acceptable. Such a value is expressed by a unit and a numeric value, such as 'EUR 4 000.00'. (Quantitative values may have statistical parameters. See section 5.4.1).

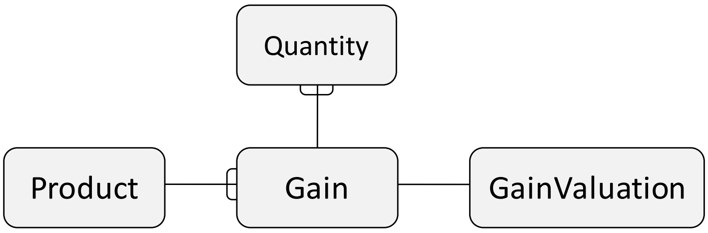


Figure 23. The schema shows that any product may be assigned many different gain-values, and each gain-value is assigned through a gain valuation. Each gain valuation results in one gain value.

The fields in the table Gain is:

```
ProductId [REFERENCING e.g. FlowId in the SPINE data structure
or similar in the ISO/TS 14048 data structure]
QuantityId [REFERENCING Quantity.Id]
GainValuationId [REFERENCING GainValuation.Id]
```

5.2 The costs, internal and external costs

The table cost is structured similar to how gain values are structured. Note however that the cost valuation in section 5.4.3 is structured differently than the gain valuation in section 5.4.2.

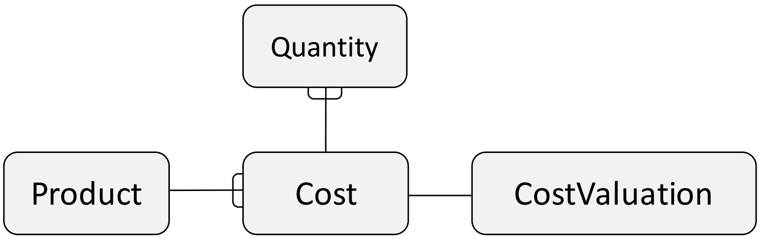


Figure 24. The schema shows that any product may be assigned many different cost-values, and each cost-value is assigned by a cost valuation. Each cost valuation results in one cost value.

The fields in the table Cost is:

```
ProductId [REFERENCING e.g. FlowId in the SPINE data structure
or similar in the ISO/TS 14048 data structure]
QuantityId [REFERENCING Quantity.Id]
CostValuationId [REFERENCING CostValuation.Id]
```

5.3 Efficiency, the compass

The eco-efficiency is a holistic comparison between the identified gain acquired from a product and the direct and indirect costs allocated to the full life cycle of the product. The most commonly performed comparison is to calculate the ratio between scalar values of gain and cost (see formula 1 and 2), but it is also common to consider the two values as coordinate pairs on a two-dimensional diagram (see also figure 22). Other examples of holistic and qualitative comparison methods that result in eco-efficiency measures is to identify cost and gain distributions throughout different life-cycle stages or to present data according to benefactors from gains vs. carriers of costs, etc. Figure 25 represents a schema that allows for any such eco-efficiency presentation.

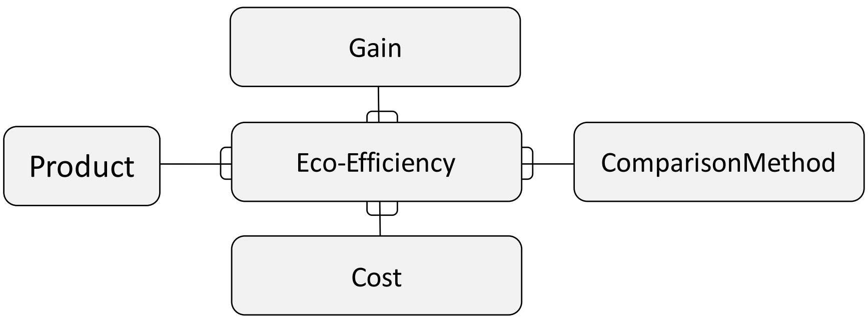


Figure 25. The schema representing the eco-efficiency of a product. A product may be assigned many different eco-efficiency values depending on which method is applied.

5.4 Library of common data types

5.4.1 Quantity

A quantity is supplied with a numerical value, statistical parameters (Statistics) and descriptive information such as when the data is retrieved, the type of data source, numerical treatment of the data etc. (MetaData). The unit of the quantitative data is selected from a library of units listed in Unit.

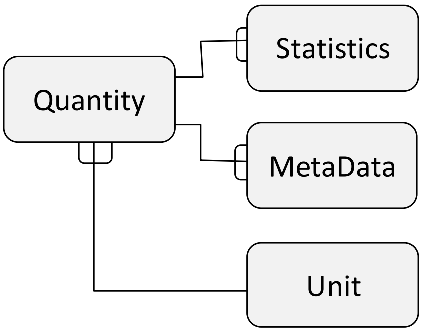


Figure 26. The data structure of a quantitative entity.

The fields in the table Quantity:

```
Id [an alphanumeric identifier, such as'ABC123']
Amount [a quantitative value]
Unit [REFERENCING Unit]
```

The fields in the table Statistics:

```
QuantityId [REFERENCING Quantity]
Parameter1 [a quantitative parameter value]
Parameter1Name [for example 'Min value']
Parameter2 [a quantitative parameter value]
Parameter2Name [for example 'Max value']
Parameter3 [a quantitative parameter value]
Parameter3Name[for example 'Standard deviation']
StatisticsName [for example 'Range']
StatisticsExplanation [if necessary, an explanation of the
                      statistics]
```

The fields in the table MetaData:

```
The fields are the same as in the tbale QMetaData in the SPINE
format (Carlson et al, 1995)
```

The fields in the table Unit:

```
Name [any suitable name, such as 'SEK', 'ELU', '$',
     'SEK/tonne', 'ELU/year', '$/square mile',]
Description [if necessary, a description of the unit]
```

5.4.2 Gain valuation

A product may be valued differently by different valuators and in different situations and based on different valuation methods. Therefore, to make it possible for anyone to interpret the meaning of a quantitative value, it is necessary that the valuator, the actual valuation and the valuation method are documented together with the gain value.

A comparison between the data structures for gain valuation and the cost valuation it is noteworthy that the gain valuation method is simpler. The reason is that this data structure is developed from the viewpoint where gain values are most often acquired by less transparent or less complex methods, such as price statistics or appraisal of value.

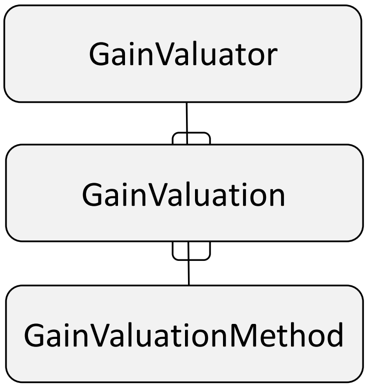


Figure 27. The data structure of gain valuation.

The fields in the table GainValuator:

```
Id [an alphanumeric identifier, such as'ABC123']
Name [an alphanumeric name, such as 'John Ericsson', 'World
      bank' or 'Citizens of Göteborg']
ContactAddress [The name and contact address to contact person]
Description [A description of role, competence, etc of the gain
             valuator]
```

The fields in the table GainValuationMethod:

```
Id [an alphanumeric identifier, such as'ABC123']
Name [an alphanumeric name, such as 'Sales price', 'Design
      price target', 'Resource value', etc.]
Reference [Literature reference or name and contact address to
           a responsible contact person and/or organization]
Description [A description of the gain valuation method]
```

The fields in the table GainValuation:

```
Id [an alphanumeric identifier, such as'ABC123']
GainValuator.Id [REFERENCING GainValuator.Id]
GainValuationMethod.Id [REFERENCING GainValuationMethod.Id]
ValuationDate [The date when the valuation was performed]
ValuationParameters [Observed parameters during valuation, such
                     as number of sold products, specific
                     market demands, lack of availability of
                     competing products etc.]
ValuationLimitations [Noteworthy omissions or limitations to
                      the validation, such as use of temporal
                      spot market prices, changes in price to
```

```
                              next product version, model assumptions
                              concerning resource values, etc]
   ValuationValidity [Describing any information that clarifies
                          the validity of the gain value]
```

5.4.3 Cost valuation

The life cycle costs and the external costs may be valued differently by different valuators, in different situations and based on different valuation methods. Therefore, to make it possible for anyone to interpret the meaning of a quantitative value, it is necessary that the valuator, the actual valuation and the valuation method are documented together with the cost value.
A comparison between the data structures for gain valuation and the cost valuation it is noteworthy that the cost valuation method is more complex. The reason is that the cost valuation data structure is developed from the viewpoint where costs most often are valued by applying complex scientific cause-effect methodologies. The data structure allows for transparent references to such cause-effect models.

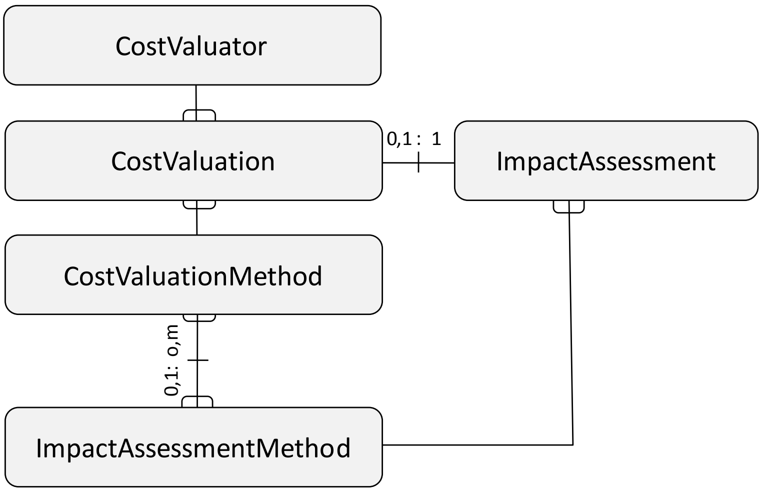


Figure 28. The data structure of cost valuation.

The fields in the table CostValuator:

```
Id [an alphanumeric identifier, such as'ABC123']
Name [an alphanumeric name, such as 'John Ericsson', 'UNEP' or
      'Stakeholders along supply chain']
ContactAddress [The name and contact address to contact person]
Description [A description of role, competence, etc of the cost
             valuator]
```

The fields in the table CostValuationMethod:

```
Id [an alphanumeric identifier, such as'ABC123']
ImpactAssessmentMethodId [REFERENCING
ImpactAssessmentMethod.Id, such data structure is defined in
Carlson et al 2002]
```

Name [an alphanumeric name, such as ’EPS 2000’, ‘LCC based on purchase cost’, ‘Combined EcoIndicator and LCC purchase cost’, etc.]

Reference [Literature reference or name and contact address to a responsible contact person and/or organization]

Description [A description of the cost valuation method]

The fields in the table CostValuation:

Id [an alphanumeric identifier, such as’ABC123’]

ImpactAssessmentId [REFERENCING ImpactAssessment.Id, such data structure is defined in Carlson et al 2000]

CostValuator.Id [REFERENCING GainValuator.Id]

CostValuationMethod.Id [REFERENCING GainValuationMethod.Id]

ValuationDate [The date when the valuation was performed]

ValuationParameters [Observed parameters during valuation, such as list of environmental impact categories and category indicators, social responsibility parameters, waste management scenarios etc.]

ValuationLimitations [Noteworthy omissions or limitations to the validation, such as use of specific databases, uncertain models, model assumptions concerning resource values, etc]

ValuationValidity [Describing any information that clarifies the validity of the cost value]

REFERENCES

Carlson R., Löfgren G., Steen B.; "SPINE, A Relation Database Structure for Life Cycle Assessment"; Swedish Environmental Research Institute, IVL-Report B 1227, Göteborg, Sweden, 1995

Carlson R, Forsberg P "The RAVEL_Information Platform Data Model" 2000 RAVEL project doc nr CPM-000919, Chalmers university of technology, Göteborg, Sweden, 2000

Carlson R., Pålsson A-C. "Documentation of environmental impact assessment, compatible with SPINE and ISO/TS 14048" IMI-report 2002:1, Chalmers university of technology, Göteborg, Sweden, 2002

ANNEX

FULL SCHEMA