4.9 Integral consideration methods

Introduction

There are various methods for inventorising the environmental burden of a process or product. The methods explained here have been selected on the basis of operationality and applicability within companies.

Three types of assessment methods can be distinguished:
- The first is a method for determining in a standard way the costs of environmental measures: the KE (Kosteneffectiviteit, i.e. Cost Effectiveness) method.
- In addition, there are methods for determining the avoided environmental burden in the form of a figure or a score, but which do not express it in an amount of money (non-monetarised result).
- The third group are methods that express the environmental burden ultimately avoided in an amount of money (monetarised result).

When the avoided environmental burden is expressed in an amount of money and it is compared with the costs of the environmental measure, the PMM (Prioritisering van Milieumaatregelen, i.e. Prioritisation of Environmental Measures) method is comparable to a cost-benefit analysis. Cost-benefit analyses in the environmental policy are used increasingly more in Europe.
A measure would, in principle, be acceptable when its cost effectiveness is favourable. To be sure, the assessment of environmental measures must be done with the necessary caution because cost-benefit analyses are highly prone to uncertainties. A tiny change in the assumptions concerning, for instance, interest rates and shadow prices can dramatically influence the result.

In the descriptions, the structure of the different methods is discussed in main lines. Furthermore, it is indicated where the methods differ from one another. For a complete description of the methods, refer to the references.

1 Cost calculation

KE, the cost effectiveness of environmental measures

The 'cost effectiveness method' makes it possible to make a clear calculation of the cost effectiveness of end-of-pipe environmental measures in industry. In principle, the method also suffices for process-integrated measures, taking into account, however, that neither the method nor the indicative reference values have been tested extensively for these kinds of measures.

The cost effectiveness method and the associated indicative reference values for cost effectiveness are tools for permit issuance. The results should be used with the necessary caution.

This method is a standard working method for calculating the costs of environmental measures at company level. Due to the standardised working method, the result is independent of the internal costs calculated by a company itself. The method is of particular importance in comparing the calculated cost effectiveness with the indicative reference values (see NeR §2.11.3 and Appendix 4.13) and in a mutual comparison of measures.

2 Non-monetarised consideration methods

The following methods compare the environmental effects in accordance with a specific weighting. Here the costs of measures for the permit holder are not shown separately.

CML method

The CML (Centrum voor Milieukunde van de Universiteit Leiden, i.e. Centre for Environmental Science of Leiden University) method is meant for comparing products or for designing environmentally-friendlier products. In accordance with the CML method, the calculation of the potential effect of a product or production process in main lines takes place in the following phases:
1 inventory of emissions
2 calculation of impact on a specific environmental theme
3 (weighting between environmental effects)
4 interpretation
The CML method has recently been updated.

Effects on environmental themes that can be taken into consideration are:
- depletion of a-biotic resources 2
- impacts of land use
- climate change
- stratospheric ozone depletion
- human toxicity
- ecotoxicity
- photo-oxidant formation
- acidification
- eutrophication
- impacts of ionising radiation
- odour
- noise
- waste heat

The assessment of all these environmental themes is not equally far developed. Only a few characterisation factors are known for some environmental themes, including 'odour' and 'waste heat'.

The characterisation factors are calculated using models based on European averages. The model for the themes of human toxicity and ecotoxicity contain, for example, information on the spread of a substance in the average European environment (depending on degradability and solubility of the substance), on possible exposure routes for humans and on the toxicity of the substance for ecosystems and humans.

In the CML method, the weighting between the themes is seen as an optional step. According to ISO standards (ISO 14042), weighting between the themes is not permitted when an LCA (Life Cycle Analysis) is used for comparative study in a public debate. When a weighting is nevertheless performed between the environmental themes, this must be done preferably with a complete nationally or internationally-accepted set of weighting factors. As long as such sets of weighting factors are not available, a case-dependent set of weighting sets must be used. Instructions for setting up a set of weighting factors are given in the manual.

The advantage of the CML method is that it describes the state-of-the-art in the LCA field and embeds the LCA technique in procedural rules. These rules were often ignored in the past. The CML method is very extensively described in a practical manual. The advantage of the CML method is at the same time its disadvantage, The CML method is suitable for making complex analyses, but less suitable for a rapid screening of environmental measures. Use of the CML method means making very many methodological choices. As a result, for example, the lack of a generally-accepted set of weighting factors for all combinations of environmental effects will be experienced as a problem. A description of the complete method including software tools is available at no cost on the CML website (http://www.leidenuniv.nl/cml/lca2/index,html). The characterisation will probably be updated in the future.

VNCI method

The VNCI (Vereniging van Nederlandse Chemische Industrie, i.e. Association of the Dutch Chemical Industry) method (NNCI, 2000) is a slightly simplified version of the new CML method specifically aimed at making visible the environmental effects of the emissions of chemical companies. The method is intended to provide a clearer perception of environmental reports; it is not simply a method for prioritising environmental measures.

The calculation of the potential environmental impact of a company proceeds in main lines by means of the following steps:

1 inventory of emissions
2 calculation of impact on a specific environmental theme
3 weighting between the different themes

Seven environmental themes are considered, namely: climate change, depletion of the ozone layer, acidification, photochemical oxidant formation, human toxicity, ecotoxicity and eutrophication. If necessary, more environmental themes will be added at a later stage. Emissions to the soil are not included, because they do not occur in the chemical industry except in the event of calamities. That is why this method is less suitable for chain analysis or branches of industry where emissions to the soil (still) do occur.

After the inventory of the emissions, step 2 is carried out by multiplying the scale of the emission with a weighting factor. The weighting between the themes is not done quantitatively.

The environmental indicators used in the VNCI method are the same as the characterisation factors in the CML method. A complete description of the method can be found in the report "Guideline Environmental Theme Indicators for the chemical industry" (Handleiding milieuthemakengetallen voor de chemische industrie). This report can be ordered from the VNCI (http://www.vnci.nl).

Eco-indicator 99 method

The Eco-indicator method is intended for comparing products or designing more environmentally-friendly products. The set-up of the Eco-indicator method differs substantially from the VROM/CE, CML and VNCI method. Central in this method is that the valuation of the emissions or the effects on an environmental theme is the most controversial step in a LCA procedure. The Eco-indicator method is developed in such a way that the step from valuation can be taken as easily as possible. This has been done by making the number of themes that must be weighted against each other as small as possible and by making the themes to be weighted as concrete as possible.

From this precondition, three themes were arrived at that can ultimately be weighted against each other, namely:

- Human health
- Ecosystem quality
- Natural resources

In the Eco-indicator method, four methods are used to link the emissions to potential damage to the three end themes.

a Calculation of damage to human health
The calculation of damage to human health proceeds in four steps:
1 Calculation of spread, where the emission is linked to an environmental concentration.
2 Calculation of dose, where a (temporary) environmental concentration is linked to a dose.
3 Calculation of effect, where the dose is used to calculate the effects on health, such as lung problems, risk of cancer (type).
4 Calculation of damage, where the effects are converted to Years Lived Disabled (YLD) and Years Life Lost (YLL).

b Calculation of damage to the quality of the ecosystem
The calculation of damage to the quality of the ecosystem is done with two methods. The effect of the emission of toxic substances, acidifying substances and nutrients is calculated in the following steps:
1 Calculation of spread, where the emission is linked to an environmental concentration.
2 Calculation of effect, where concentrations are linked to toxic stress or increased nutrient and acid levels.
3 Calculation of damage, where the effects are linked to potentially disappeared fractions of plants.
The second method is used in land use and land use changes. These are modelled on the basis of empirical data on the quality of the ecosystem as function of surface area and type of land use.

c Calculation of damage to natural resources
Damage to natural resources is modelled in two steps:
1 Estimate of the amount of natural resources, where extraction is linked to a decrease of the amount.
2 Calculation of damage to natural resources, where a decrease of the concentration of a natural resource is linked to an increasing effort that must be made to exploit the natural resource.

The result of these calculations is a figure for the damage to natural resources, the damage to ecosystems and the damage to human health. This method still contains large gaps when it comes to translating the effects on an environmental theme into damage to the safeguard subjects.
In practice, damage to a safeguard subject per emission is expressed in a figure: DALY for damage to human health; PAF and PDF for damage to the quality of the ecosystem. For damage to natural resources, surplus energy in MJ per kg of extracted material is used.

The damage caused by one emission to a safeguard subject is calculated by multiplying the emission in kilogram of substance with its characterisation factors, so that finally the total score on the three safeguard subjects can be calculated.
In a final step, these three categories must be standardised and weighted against each other. The weighting of the three different damage categories can be done with the aid of a panel procedure. Standard weighting factors are available that have been obtained with such a panel procedure.

The Eco-indicator method goes further than the CML, VNCI and the distance-to-target methods. These methods do not go further than calculating the effects of an emission, after which, if necessary, the different effects are weighted against each other. These are so-called mid-point methods; the Eco-indicator method is an endpoint method.
A problem with the Eco-indicator 99 method is that in modelling the environmental effects according to damage only a few damage mechanisms can be used. In the translation of an environmental effect into damage, much information is lost. In addition, due to the very poor calculation a weighting is implicitly made between the categories, because the translation of the one environmental effect into environmental damage is much more complete than that for another environmental effect.

A full description of the Eco-indicator method can be downloaded from the website of Pré Consultants (http://www.pre.nl/eco-indicator99/default.htm). Pré Consultants also supplies software tools and LCA data for a charge.

3 Monetarised methods

Shadow Price method

The Shadow Price method (Wit et al. 1997) has been specifically developed for prioritising environmental measures within companies (in the original publication it is called shadow price prioritisation method). The entire method comprises both the determination of the environmental effect of a measure and the business-economic effect of a measure along with the resulting prioritisation on the basis of cost effectiveness and other requirements such as statutory requirements and technical limitations. Since in this project only one way of calculating the business economic effects is used, the method for determining the environmental effects alone will be considered.

The purpose of determining the environmental effect is to express the total environmental effect during the entire life cycle of a measure in a single figure: the total net environmental benefits.

The total net environmental benefits are established in four steps:
1 Inventory of the annual emission reduction.
2 Determination of the annual effect score per theme of the emissions.
3 Financial valuation of the annual environmental effects.
4 Determination of the total net environmental benefits.

After the inventory, step 1, the emissions must be translated into an effect on a specific environmental theme. Environmental themes considered are:

- safety risks
- intensified greenhouse effect
- ozone depletion
- acidification
- photochemical oxidant formation
- spread of toxic substances
- eutrophication
- removal of final solid waste
- disturbance through noise and odour
- soil damage

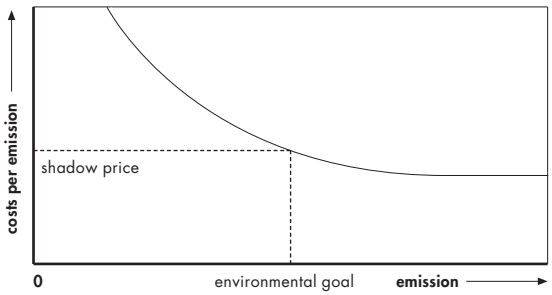
Use is made of equivalence factors to calculate the effect of an emission on one of the above-mentioned themes. These equivalence factors can be the same equivalence factors as used in the obsolescent CML method. The Shadow Price method does, therefore, not differ from the CML method up to and including step 2. Assigning weight to a specific effect on a theme is different in the Shadow Price method than in the CML method.

The shadow price represents the market price that would probably arise if there were a market of supply and demand for the environment. The shadow prices are based on the costs of measures that would have to be taken in order to meet the environmental goals established by the government. A shadow price is established for each individual environmental effect. The shadow price is determined by the most expensive measures that are minimally necessary (the marginal prevention costs) in order to meet the government goals. The derivation of the shadow price dependent on an environmental goal imposed by the government is shown in Diagram 1.

To determine the shadow prices, the Dutch environmental goals have been used. The shadow prices apply, therefore, only to the Netherlands. Because in step 3 the effect of all interventions on all environmental themes is expressed in a single unit (money), the mutual environmental effects can be compared in step 4. In this final step, the financially-valuated annual environmental effects are added up and expressed in the environmental benefits of a measure.

Shadow prices are available, in so far as they arise from projects conducted by CE-Delft (http;/www.ce.nl) for clients. Keeping the shadow prices up-to-date is dependent on projects in which it is necessary to calculate new shadow prices.

Diagram 1



Calculation of the shadow price of an emission on the basis of an environmental goal and the costs of the measure for preventing the emission.