Annex 2a. Background information on norms for sustainability.

Concentration levels.

For The Netherlands there is a set of 'target concentration levels' (Dutch: 'streefwaarden') for 210 pollutants, which are to be used as 'norms for sustainability', known as the 'milieukwaliteitsnormen INS '97'[1] . This data set has been developed on scientific grounds (as far as it was possible) to provide a solid basis for the environmental policy of the Dutch government.
The 'target concentration levels' are derived from risk assessment for each pollutant, and are based on the following three parameters:
- the Maximum Allowable Risk Level (Dutch: MTR)
- the Negligible Risk Level (Dutch: VR), being 1/100 of the MTR
- the Natural Background Level.

The MTR is a level at which 95% of the potentially resident species are safeguarded when there are no other pollutants (for carciogenics: less than 1 fatal illness per 1 million inhabitants).
The discussion about the MTR is, however, that a *combination* of pollutants might cause a more severe situation. Therefore the VR, in most cases 1/100 of the MTR, is introduced as a level which can be considered as safe. However, in some cases the VR is lower than the Natural Background Level. Therefore the 'target concentration level' for a pollutant is:
- the VR when the VR is more than the Natural Background Level
- the Natural Background Level when this is more than the VR.

One may conclude that the set of 'target concentration levels' is the best guess which can be made at this moment, given the state of science. Although further developments can be expected, the changes in this kind of data during recent years are not of a drastic character. Thus this set of 'target concentration levels' may be considered as good enough for the time being.

The situation with regard to the greenhouse effect seems to be more blurred. It is not clear which concentration of greenhouse gasses is sustainable.
The only facts which are available, are the political decisions of Kyoto, and the 'guts feel' of the majority of the experts, who think that a reduction of 50% in the far future will be good enough (Gielen, 1999).

The relationship between the concentration and the damage.

It has to be mentioned here that the relationship between the concentration of a pollutant and its damage is not known for any of the pollutants: is the relation linear? logarithmic? s-curve type? See Figure A.2.1. It is obvious that one point on the curve (the MTR) is much easier to determine than the shape of the total curve.

Most of the models of a single indicator based on the *damage* of emissions, implicitly assume a linear relationship between emission and damage. This requires a linear function through the origin of the concentration-damage curve (see Figure 1) which is not likely to be the situation in reality! The introduction of *marginal* damage costs is *not* sufficient to tackle this linearity problem in LCA.
Prevention based models don't apply a concentration-damage relationship: prevention measures have to bring the concentration under the Maximum Allowable Risk Level, where damage is negligible. Prevention based models apply therefore only *one point* on the damage-concentration relationship of Figure A.2.1.

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[1] Integrale Normstelling Stoffen, milieukwaliteitsnormen bodem, water, lucht, december 1997, Interdepementale Werkgroep Integrale Normstelling Stoffen. See also World Health Organization, 1995, Update and revision of the Air Quality Guidelines for Europe and the Water Quality Guidelines for Europe.

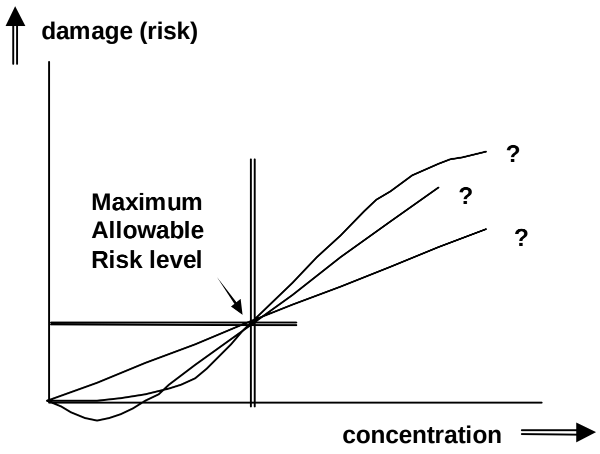

Fig. A.2.1: The shape of the concentration-damage curve for pollutants is not known

Emission rates

Starting from the situation that the set of ‘target concentration levels’ is fairly well known, it is ,however, not easy to calculate the corresponding ‘maximum sustainable emission rate’.

When the rate of decay (or absorption) is known, it is possible to determine the ‘maximum sustainable emission levels’ because these levels can be calculated for the “steady state of a closed region” (i.e. the total sustainable emission in that region is set equal to the decay or absorption rate of that pollutant at the maximum allowable air or water concentration). When we assume a (pseudo)first order reaction for decay or absorption, the equation for the ‘maximum sustainable emission rate’ can be derived:

first order reaction: $\mathrm{d}c/\mathrm{d}t = \phi/V - k*c,$ [A.2.1]

where: c is the concentration of the pollutant (kg/m3)
t is the time (s)
k is the reaction rate constant for the decay or the absorption(1/s)
ϕ is the emission rate (kg/s)
V is the volume of air or water (m3)

for the steady state: $k*c = \phi/V$ [A.2.2]
or, for the maximum sustainable level: $\phi_{max} = k*c_{max}*V$ [A.2.3]

where: ϕ_{max} is the maximum emission rate which is just sustainable (kg/s)
c_{max} is the maximum allowable concentration of the pollutant (kg/m3)

In reality it is more practical to define equation [A.2.3] in terms of the “immission rate” ,I , which is defined as the load rate of pollutant (kg/s) per square meter of area, A :

$I_{max} = k*c_{max}*d$ [A.2.4]
and: $I_{max} = \phi_{max}/A$

where: d represents the average thickness of the polluted layer:
e.g. in water: the volume of water in a certain area divided by the area surface,
in air: for summer smog the height of the inversion layer in the air
in soil: the penetration depth of the pollutant

Unfortunately, there is no full consensus about decay and/or absorption rates (e.g. part of the debate on global warming concentrates on the absorption rate of the earth of CO_2).
De Boer (Dellink et al., 1997) gives a calculation for the Dutch situation for acidification, eutrophication, summer smog, winter smog and heavy metals (Zn), based on several Dutch calculation models. These calculations form the basis for verification of the norms which are given for each class of the virtual pollution prevention costs '99.
Similar calculations (the 'fate analyses') have been made in the Eco-indicator '99 model (Goedkoop, 1999), applying several European models to it.

Marginal prevention costs

A totally different norm for sustainability is the 'marginal prevention costs', applied by environmental economists.
The basic reasoning behind the marginal prevention costs can be summarized as follows:
- prevention of emission of production processes will require technical measures ('end of pipe' as well as 'process integrated')
- these measures will cost money (e.g. Euro/ 'kg prevented emissions')
- on the road to a sustainable economy, we will introduce the most cost effective measures first
- the last and most expensive measure for pollution prevention, required to reach a sustainable economy, has a certain level of costs per 'kg prevented emission': *the marginal prevention costs*.

This is depicted in Figure A.2.2. The measures to be taken form curve a. The marginal prevention costs are determined by the slope of curve a where the norm for sustainability is met: the slope of line b.
Note that the total required prevention costs to reach the norm are less than the distance to the norm multiplied by the marginal costs (as is indicated by line c). See also Annex 2c for a further explanation.
One of the advantages of the marginal prevention costs as a norm is that these costs do not change when measures are implemented, where the "distance to target" changes continuously in time.

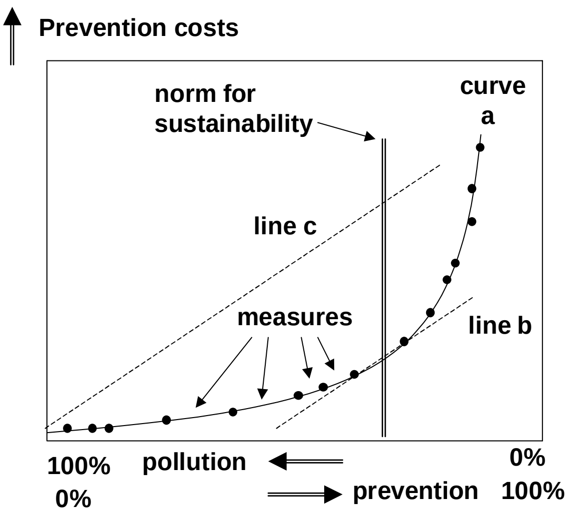

Fig. A.2.2: A typical cost curve of reduction of pollution and the marginal prevention costs

There are several ideas to trigger the required change process on a National, European or even world wide, level. To name a few:
- taxation of emissions ("the pollutant pays") at the level of the marginal prevention costs: companies will apply the cheaper measures, where possible, rather than pay the tax

- introducing ‘tradable emission rights’ at the price of the marginal prevention costs: again, companies will use each opportunity to apply measures which are cheaper than these emission rights
- agree with the industry that they will introduce a list of measures (of which the most expensive measures are at the level of the marginal costs), a so called ‘convenant’ to apply the ‘best practices’
- force the industry to introduce the measures up to the level of the marginal prevention costs and ban the processes which cannot be accepted (for example the ban on CFCs)
- try to influence the demand side of the market to accept environmentally clean products only.

The prerequisite of these ideas is that our society is prepared to pay the extra costs up to the level of the marginal prevention costs in order to create a sustainable world, and that the measures have to be introduced in the most cost-effective way from the National point of view. See also Chapter 9 and Annex 2c.

Since the concept of marginal prevention costs is easy to understand, it generates a lot of questions such as:
- what is the level of sustainability for each class?
- what is the ‘willingness to pay’ [2] for each class?
- will ‘economies of scale’ and technological innovation make pollution prevention less expensive, resulting in a lower level of marginal prevention costs?
- will economic growth and growth of the population make the sustainability norms harder to reach in future, resulting in a higher level of marginal prevention costs?

The model of the virtual pollution prevention costs ’99 is based on the present situation, and *not* on the future. The validation of the levels of marginal prevention costs are based on the present state in ‘virtual’ terms (“what if we already had taken the measures now”). These calculations are based on the aforementioned ‘target concentration levels’ (Dutch: ‘streefwaarden’), which are accurate enough “to begin with”.
The last measure for pollution prevention in the calculation of the marginal prevention costs is to be regarded as a ‘moving target’: the future will bring us the real values of marginal prevention costs (hence …..’99).

The fact that the maximum level of emissions for a sustainable society is not yet fully known, is often used as the main argument to reject prevention oriented models as being too vague. It is used as an argument to choose a damage oriented model for calculations. A rather bizarre situation since the main elements for calculations on the basis of damage *are not available at all*:
- the shape of the concentration-damage curve (where the fact that the curve is non-linear is causing enormous complications in such damage based models)
- a realistic methodology how to compare a fatal illness with dying trees and/or distinguishing species (Finnveden, 1997).

Regionality

A fundamental problem in the calculation model is how to deal with ‘regionality’ (apart from calculations on the greenhouse effect, since this effect is global).

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[2] The willingness to pay (WTP) must not be confused with the marginal prevention costs. The WTP (and the willingness to accept compensation, WTAC) are based on *valuation of damage.* Although many attempts have been made, there are still a lot of methodological flaws in such a ‘non-market valuation’, and ‘non-use valuation’ (Henley et al., 1997). There have been two major applications of the WTP:
- the valuation of the damage caused by the Exxon Valdes (by the Contingent Valuation Method, CVM)
- the EPS method (Steen, 1996)

One of the main conclusions is that information is crucial for those valuation systems: for many environmental issues, awareness is needed to bring the WPT above the level of the marginal prevention costs (to make the level of marginal prevention costs politically accepted).

In areas with a high density of population and industrial activity, stringent and expensive measures are required (to safeguard the sustainable level of the ratio ϕ/V or I/A, see equation [A.2.3] and [A.2.4]). From the mathematical point of view, however, higher emissions are allowed when they are diluted in a higher volume (bigger area). As a consequence, the marginal prevention costs will be higher when the calculation is made for the Dutch province of Zuid Holland, than it is for The Netherlands, or for Europe. Damage based models suffer from the same fundamental problem.
From a philosophical point of view, it seems that dilution of emissions have to be avoided in the real world (so also in the calculation models). At the same time, best practices for pollution prevention should be applied on a global level to prevent ‘export’ of sustainability problems.

The aforementioned approach means that norms have to be calculated for areas with a high density of population and industry (e.g. The Netherlands, the western part of Germany, the areas of Los Angeles, Tokyo, etc.). The required pollution prevention measures should then be applied world wide, however, not at a cost level which is higher than the marginal prevention costs (example: a windmill is only a good solution in areas with a lot of wind). So the idea of economic feasibility (‘cost effectivity’) plays an important role in such a model.