ANNEX 5 ENVIRONMENTAL IMPACTS ANALYSED AND CHARACTERISATION FACTORS

CONTENTS

1.1 Introduction

This annex gives detailed explanations about the environmental impacts (or ‘impact category indicators’) and characterisation factors considered in section 8.1 of this report dealing with plastic resins recycling and recovery.

1.2 Impact assessment

Reminder (see section 8.1.3: an impact assessment is carried out in order to condense the information contained in the inventory. For this, the environmentally significant material flows compiled in the inventory must be described in terms of their potential impact on the environment.

1.3 Impact category indicators

Area of protection	Impact category	Scientific unit for the indicator	Reliability of the calculation methods	Confidence in the inventory data
Consumption of resources	Total energy	MJ	+++	+++
Air pollution	Global warming potential	g eq. CO_2	+++	+++
	Acidification potential	g eq. SO_2	++	++
	Photochemical oxidation	g eq ethylene	+	+
Water pollution	Eutrophication potential	g eq. PO_4	+	+
	Water pollution (critical volume)	m^3	+++	++
Waste	Municipal waste	kg	+++	+++
	Hazardous waste	kg	+(+)	+(+)

Source: BIO Intelligence Service, 2005

1.4 Sources of uncertainty

Two basic kinds of uncertainty have to be distinguished: the first one is due to the calculation modelling (used to describe a physical phenomenon), the other one is introduced as far as the inventory dataset may be reliable and accurate.

The soundness of every impact indicator is scored ('+++' high reliability to '+' = very low reliability) in the table above. The scores for the reliability of the calculation methods are representative of the today's state of the art for impact assessment within the LCA framework; additional works are in progress to improve the indicators related to human and ecosystem health.

1.5 Total energy

Energy carriers are divided in renewable and non-renewable resources. For determining the energy content of resources, the method considers the fundamental material input and the net calorific value. This is done irrespective of whether the resources are to serve for material purposes or for energy refining. For the latter, the following methodology is generally employed in LCA studies.

The energy demands of an analysed system (as far as fossil fuels are concerned) are traced back in the inventory to the removal of the primary energy carriers from a raw materials source.

Based on the material input (given in mass unit in the inventory), the resource demand can be assessed by taking the net calorific value because for the majority of technical applications the net calorific value and not the gross calorific value represents the relevant information.

For the assessment hydropower, the potential energy of the water before energy production is assumed in order to ascertain the resource demand. The demand of nuclear power is expressed in uranium equivalents (given in kWh) for the energy production. It is thus possible to quantify resource demands in the inventory even for non-material energy resources.

1.6 Global warming

When determining the climatic impact of a substance, the Global Warming Potential (GWP) is used. This is a measure of the effect on radiation of a particular quantity of the substance over time relative to that of the same quantity of CO_2. The GWP depends thus on the time spent in the atmosphere by the gas, and on the gas's capacity to affect radiation, which describes the immediate effects on overall radiation of a rise in concentration of the gas.

The GWP is calculated with combined climatic and chemical models and covers two effects: the direct effect a substance has through the absorption of infrared radiation and the indirect chemical effects on overall radiation.

In the life cycle assessment of the end-of-life of plastic parts from ELVs, radiation effects due to CO_2, methane (CH_4) and nitrogen protoxide (N_2O) are considered in the impact assessment.

The GWP value for CO_2 is chosen as equivalence factor. Considered over a time span of 100 years, methane should have a GWP CO_2 value of 21, and N_2O a GWP of 310.

1.7 Acidifying gas emission and Acidification of land and water

In order to describe the acidifying effect of substances, their acid formation potential (ability to form H+ ions) is calculated and set against a reference substance, SO_2.

Table 1: SO_2 Equivalence Factors of Various Acid Producers

Acid producer (in air)	SO_2 equivalence factor
1 kg HCl	0.88 kg eq SO_2
1 kg HF	1.60 kg eq SO_2
1 kg NO_2	0.70 kg eq SO_2
1 kg SO_2	1.00 kg eq SO_2
1 kg H_2S	1.88 kg eq SO_2
1 kg NH_4	0.89 kg eq SO_2
1 kg NH_3	0.93 kg eq SO_2

1.8 Formation of photochemical oxidants

As a measure for estimating airborne substances' potential for forming atmospheric oxidants, POCP (Photochemical Ozone Creation potential) values are used. The POCP value of a particular hydrocarbon is a relative measure of how much the ozone concentration measured at a single location varies if emission of the hydrocarbon in question is altered by the same amount as that of a reference hydrocarbon, usually ethylene.

The POCP value is not a constant, but can very over distance and time, since formation of oxidants along the path of an air pocket is determined by the composition of the prior mixture and the meteorological conditions, which can also vary spatially and chronologically.

In the LCA inventory, the greater part of the hydrocarbon emissions appears as group parameters (e.g. "NMVOC": non methanic volatile organic compounds, or "hydrocarbons, classified").

Therefore, the resulting value for this indicator may be considered as approximate.

The characterised factors used in the Fraunhofer study are not detailed in the Fraunhofer report.

1.9 Nutrification of land and water (eutrophication potential)

Additional input of plant nutrients into water can bring about excessive growth of water weeds (phytobenthon), free-floating plant organisms (phytoplankton) and higher plant forms (macrophytes). This does not only represent a change in the stock of a species, but also in the balance between species. Due to the increased generation of biomass and the consequently heavier sedimentation of dead organic material, the oxygen dissolved in deep water is consumed faster, through aerobic decomposition. This can lead to serious damage in the biological populations inhabiting the sediment. In addition to this, direct toxic effects on higher organisms, including humans must be taken into account when certain species of algae appear in mass.

While phosphorus determines the degree of eutrophic activity in the majority of cases in the limbic area, in marine and terrestrial ecosystems nitrogen is most often the decisive factor. Equivalence factors suggested by CML (University of Leiden, 1992) are generally used in LCA.

Table 2: PO_4 equivalence factors of various substances

Nutrient	PO_4 equivalence factor
1 kg Nitrogen oxides (NOx, air)	0.13 kg eq PO_4
1 kg Total nitrogen (water)	0.42 kg eq PO_4
1 kg Total phosphorous (water)	3.07 kg eq PO_4
1 kg Chemical O_2 demand (COD)	0.022 kg eq PO_4
1 kg NH_3	0.35 kg eq PO_4
1 kg NH^{4+}	0.33 kg eq PO_4
1 kg NO^{3-}	0.095 kg eq PO_4
1 kg NO^{2-}	0.13 kg eq PO_4

1.10 Water pollution

Water emissions are calculated as critical volume. For every emission a volume of water is calculated, which is necessary to ensure sufficient dilution to an acceptable effect level in the environment. The acceptable levels for the calculations in this study are based on the German legislation (waste water regulation from 1997).

Table 3: Water pollution dilution factors of various substances (APME, 2003)

Nutrient	Dilution factor (l/mg)
COD	1
BOD	5
Total N	4
NH_4	8
PO_4	75
AOX	75
Heavy metals	75
Hydrocarbons	38

1.11 Impact categories which cannot be derived from life cycle inventory data

- Noise: it is not sensible to quantify noise emissions released within a global system (spatially and temporally located elsewhere) and to relate them as a sum parameter to an impact category.
- Odour: (see "Noise").
- Nature conservation (biodiversity, etc.): cannot be derived from life-cycle inventory data.
- Land use: inventory data are quite differently documented for the different systems.
- Risk of nuclear accidents: cannot be derived from inventory data.