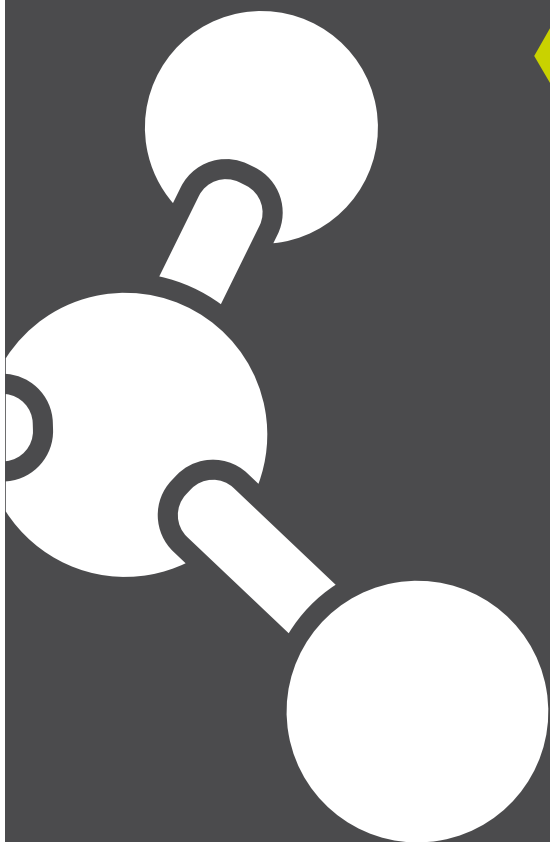




GUIDE ON **SUSTAINABLE CHEMICALS**

A decision tool for substance manufacturers, formulators
and end users of chemicals



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Amt 
For our Environment

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1.0

Introduction:
Sustainable chemicals -
yes - but how?



INTRODUCTION: SUSTAINABLE CHEMICALS – YES - BUT HOW?

Sustainable chemistry comprises of many aspects. They range from the selection of inherently safe chemicals via the assessment of environmental impacts of product lines by lifecycle analysis to the implementation of ambitious social standards in the supply chain.

Neither today nor in the future, may sustainable chemicals have unacceptable (eco-) toxic impacts on man and the environment. They may not or only insignificantly contribute to the depletion of natural resources. Furthermore, they may not cause or enhance socially precarious situations or unhealthy workplaces, however they are beneficial to the entire economy and to enterprises.

The sustainable use of (sustainable) chemicals aims at providing socially necessary products while minimising resource consumption, reducing substance losses and controlling exposures by corporate, design oriented, organizational and technical means and at the same time enhancing healthy workplaces and fair social conditions.

1.1. WHY SUSTAINABLE CHEMICALS?

The selection of sustainable chemicals can have advantages for the protection of workers, consumers and the environment. In the long run, sustainability leads to more innovative uses of chemicals and is therefore also economically attractive. Hence, a sustainable product is a product that is successful on the market, for which less dangerous substances are used and which have less adverse impacts on the environment and to the society than a comparable product.

1.2. WHY ANOTHER GUIDE?

Several approaches already exist regarding the implementation of sustainability as such. A good overview is provided in the background paper of the German Environment Agency on sustainable chemistry¹.

Numerous practical examples have been published on the implementation of single aspects of sustainability in enterprises². However, up to now guidance supporting enterprises in a systematic manner to practically implement sustainable chemistry in their daily practice is missing.

This guide assists the selection of sustainable chemicals by providing criteria to distinguish between sustainable and non-sustainable substances. It can also support a more sustainable use of chemicals, by highlighting single aspects of the evaluation. The guide is not specific to certain industry sectors, but the criteria can be used across all fields of economy.

Here we want to mention an additional approach: the HACCP-concept (“Hazard Analysis and Critical Control Point”). It is implemented for managing risks along supply chains, mainly in the food industry, but can also be used to prioritise risk management in other sectors³.

1.3. TARGET GROUP

This guide is addressed to manufacturers, formulators and end users of substances and mixtures. It supports the integration of aspects of sustainability in their selection and the way chemicals are used.

Chemical end users frequently demand specific technical standards of the products they use (substances and mixtures), like the uniformity of coloration achieved by a specific dye or a particular degree of light resistance of lacquers. In addition, requirements of workers' protection, consumer protection and environmental protection must be fulfilled. The consideration of sustainability aspects may trigger further demands, e.g. on conformity of actors in the supply chain with social standards.

Some enterprises have already implemented a sophisticated quality or environmental management system and are eager to substitute dangerous chemicals. However, small and medium sized enterprises (SMEs) normally have only little or no experience in the selection of sustainable chemicals. The guide aims particularly to support these companies.

1.4. INTEGRATION OF "NEW" ISSUES

For some aspects (e.g. avoiding chemicals with a high human toxicity) well defined decision criteria can be provided in this guide (e.g. classification as cancerogenic, mutagenic or reprotoxic of categories 1, 2 and 3).

For other aspects these criteria don't exist yet, for example on resource consumption, reduction of greenhouse gas emissions and taking social responsibility. In many industry sectors "best available techniques" have been compiled in so called BREF documents which will lead to resource savings and emission reduction if implemented⁴.

The evaluation of sustainability of chemicals is more than the traditional identification of dangerous substance properties, assessing exposures and characterising risks. Therefore, this guide also provides support for the "new" issues – even though no fully developed and quantified criteria are available.

Demands for sustainable chemicals can be better accommodated (maybe even only then!), when they are integrated not only into a company's policy and goals but also in its quality or environmental management system (including standards for success monitoring). The implementation is normally a step-by-step process.

1.5. CONTENTS AND STRUCTURE OF THE GUIDE

This guidance sets the focus on potential impacts of substances on man and the environment and on social responsibilities in supply chains. Economic aspects are

addressed to a minor extend only. Such aspects are treated in detail within the socio-economic analysis developed under REACH. It is introduced in chapter 2.2.6.

In this guide, the term "chemicals" means both substances and mixtures. The evaluation of sustainability, in particular regarding the substance-specific criteria is recommended to be performed primarily for substances as such. However, along their lifecycle they are in most cases included into mixtures (formulation) and either consumed or further processed into articles. This is reflected in the second set of criteria addressing the uses.

Formulators and end users of chemicals (= substances and mixtures) normally handle mixtures rather than substances. In this case we recommend to start the assessment of the mixture with substances of the mixture classified as dangerous. These substances are important for occupational health and environmental protection in companies. They are documented in section 3 of the safety data sheet of the mixture (in most cases, for substances which are not classified as dangerous the downstream user has no information on their properties (without a specific communication with his supplier⁵).

This guide consists of six chapters. The criteria for sustainable chemicals are introduced in Chapter 2, following this introduction. Substance-specific criteria, which only depend on the substance properties, are differentiated from use-specific criteria, which depend on the type of its application and use.

The criteria in this guide are selected according to two guiding questions:

- Which criteria can be applied by enterprises in practice for the selection of substances and mixtures?
- What types of demands can enterprises pose their suppliers that exceed those of product labels such as the Blue Angel?

Following the description of the sustainability criteria, in Chapter 3 "ten golden rules" for the selection and use of sustainable chemicals are introduced, which can be understood as simplified and aggregated sustainability criteria. The "ten golden rules" relate to the selection of sustainable chemicals connected with some important rules regarding their safe application.

In Chapter 4, the results and consequences of an evaluation are illustrated using two examples and an outlook on future developments is given. Chapter 5 provides references used in this guide and abbreviations are explained in Chapter 6. The annexes contain links and further information sources on substance lists, specific criteria, data bases and assessment systems.

1.6. THE RESULT OF USING THE CRITERIA

This guidance does not aim to give an assessment method resulting in figures of sustainability. This seems not to be appropriate regarding the complexity of the issue. However it describes criteria which can be used for a first assessment of the sustainability of substances and mixtures.

When analysing the sustainability of chemicals using the following, substance-specific criteria will result in any one of the following statements:

- > No action is needed, because available information indicates that the chemical is not “problematic” (green)
- > No action is needed, because the available information indicates problematic substance properties (yellow)
- > There is a high priority to act, because the available information indicates very problematic substance properties (red)
- > There is a need to gather further information, because no or little data is available (white)

The application of the use-specific criteria can modify the evaluation of a substance’s sustainability judged only by the substance-specific criteria, because properties assessed as problematic may, due to the type of

application, not cause any harm. Other aspects, such as very high benefits of the use of a substance may justify the continuation of its use, although it was originally evaluated as non-sustainable.

Figure 1 illustrates how the substance-specific and the use-specific criteria are interlinked.

Chapter 2.2 describes consequences of the application of the substance-specific criteria for the next step of the assessment, the application of the use-specific criteria.

Chemicals without problematic properties, which can be regarded as inherently safe will not be available in all cases. Nevertheless, there may be ways to optimize the use of problematic substances, for example by implementing risk management measures. The guiding questions are:

- > How can the emission potential of a specific use be minimized?
- > Which user groups will be exposed to the chemical?
- > How can exposures be reduced?

Related support is provided in Chapter 2.2 (use-specific criteria).

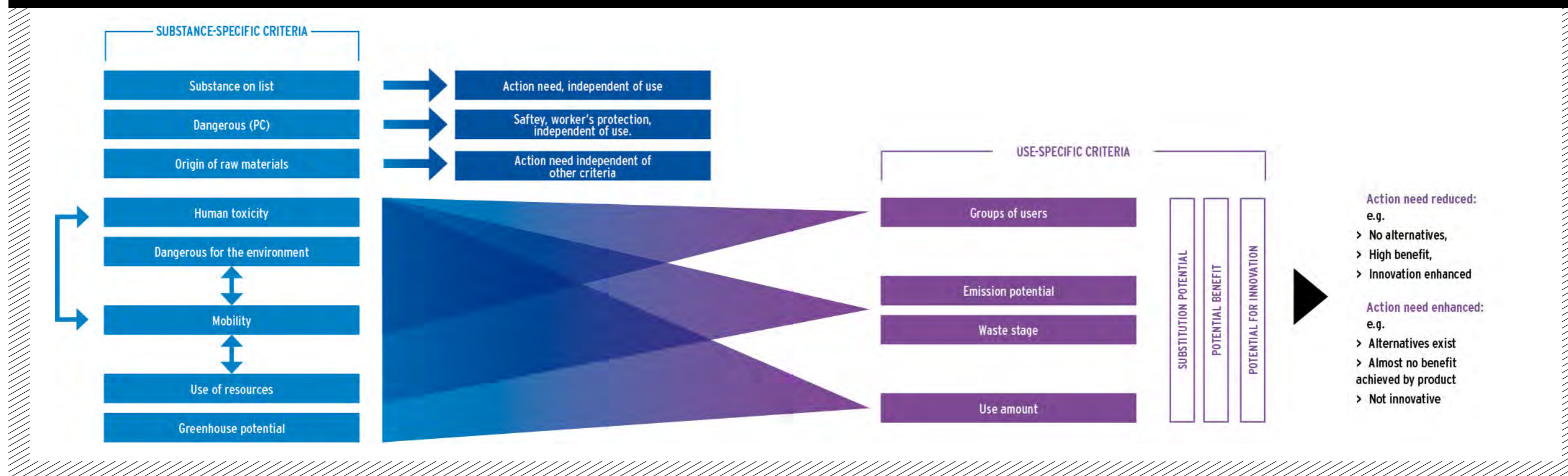
We recommend a stepwise approach:

1. For the first assessment data should be used which are readily available in the company. The resulting sustainability profile (see chapter 2.1.9) indicates areas which require further action.
2. In the next step further information is included. It might become necessary to use additional data sources. Some of them are described in Annex 4.

Sources:

- 1 http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?nfrage=Kennnummer&Suchwort=3734
- 2 For example the implementation of environmental or quality management systems, the manufacture of substances using catalysts (energy and resource savings), design for the environment integrating recyclability of products (reduction of material losses), the self-commitment to “codes of conduct” which exclude dangerous substances from products and reclaim compliance with workplace standards along the supply chain.
- 3 http://www.bfr.bund.de/cm/234/fragen_und_antworten_zum_hazard_analysis_and_critical_control_point_haccp_konzept.pdf.
- 4 <http://eippcb.jrc.es/reference/>
- 5 In case of mixtures consisting of many substances in a first step it should be clarified, which substances as lead substances are triggering the risk management measures for the mixture. Guidance for the identification of lead substances is given in Part III of the REACH Practical Guide on Exposure Assessment and Communication in the Supply Chains (<http://www.cefic.org/Files/Publications/Doc-1-Part-1-to-3-Practical-Guidance-final.pdf>).

FIGURE 1: INTERLINKS BETWEEN CRITERIA



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2.0

Criteria for selecting
sustainable chemicals



CRITERIA FOR SELECTING SUSTAINABLE CHEMICALS

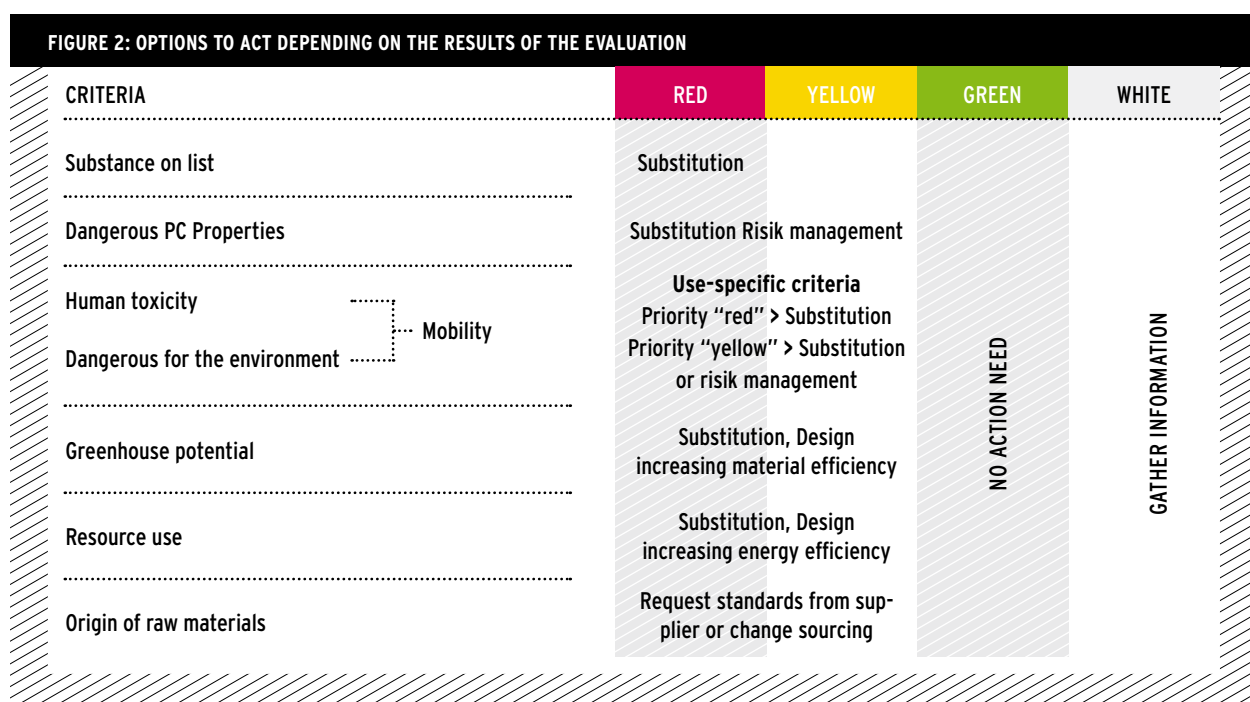
The criteria for the selection of sustainable chemicals should enable companies to systematically implement sustainable chemistry in their daily practice.

Generally, substance-specific criteria which only depend on the properties of a substance, and use-specific criteria which mainly depend on the type of its use, are distinguished. The substance-specific criteria are introduced in Chapter 2.1 and the use-specific criteria in Chapter 2.2.

application of the use-specific criteria to chemicals evaluated as “red” and “yellow” may be helpful in the prioritising of action needs. For chemicals which have been evaluated as “white”, more information should be obtained as a priority action to enable the assessment of the substances-specific criteria.

The evaluation of sustainability is based on the following eight substance-specific criteria (step 1). The

Figure 2 gives an overview of the possible options to act on, depending on the result of the evaluation.



2.1. SUBSTANCE-SPECIFIC CRITERIA FOR THE EVALUATION OF SUSTAINABILITY

For the evaluation of sustainability of chemicals, the following eight substance-specific criteria should be used as a first step:

1. Mentioning in lists of “problematic substances”
2. Dangerous physico-chemical properties
3. Human toxicity
4. Problematic properties related to the environment
5. Mobility
6. Origin of raw materials
7. Emission of greenhouse gases
8. Resource consumption

In the following paragraph, these eight criteria are described. The relevance of the criteria regarding human health, the environment, society and the economy is explained as well as their applicability. Additionally, possibilities to obtain information on certain aspects are discussed.

Some products require properties which automatically result in an assessment as being “less sustainable”. E.g. can preservatives are used to prevent microbial degradation of lacquers. This requires a biocidal activity of ingredients which are hazardous to the environment. In such cases a problematic property has to be accepted to achieve the required function of the product.

If criteria refer to properties which are essential for the function of the product, it might be that these criteria become less important for the overall assessment of the product.

If the function of a product requires problematic properties, it should be carefully checked whether it is possible to achieve the same function by a different product design. This includes alternative solutions without chemicals, e.g. constructive solutions for flame protection. In any case – including alternative solutions without chemicals – the assessment of the alternative solutions has to cover the different potential impacts on man and the environment (e.g. energy consumption in case of vegetation control using heat). Details on the assessment of substitutes are given in chapter 2.2.5 of this guidance.

The sustainability of chemicals based on their intrinsic properties is evaluated using tables with specific indicators, which are included at the end of each section. To improve understanding, the colours “green”, “yellow”, “red” and “white” are used to indicate the evaluation result. The following explains what each colour means:

- › **Green:** there are no indications of critical properties, no action needed,
- › **Yellow:** there are indications of problematic properties; further analysis with use-specific criteria is necessary,
- › **Red:** the substance is obviously problematic. Substitution possibilities should be assessed with high priority,
- › **White:** Information is not sufficient for an evaluation. Further information should be gathered.

Some criteria consist of several sub-criteria. Here, the overall evaluation results from the integration of all sub-criteria into one. The sub-criterion with the worst evaluation determines the overall result (results are not averaged!). The sequence of “severity” is:



The action requirement is highest for red and lowest for green. In case of “White” a high need for further action is required to get sufficient information for the assessment.

Note: The assignment of colours and indicators to the criteria is a proposal of the editors, which is based on the expertise of the persons involved.



EXKURSUS:

in the past, much substance-related empirical data has been generated for assessing risks and classifying and labelling substances. This data, which was and is required among others in legislation on supply chain communication, is an important information basis for the evaluation of a substance's sustainability. In general they are communicated with the safety data sheets. Therefore, some of this data is explained in Annex 5.

2.1.1. Mentioning on lists of problematic substances

Substances with particularly dangerous properties for man and the environment may already be regulated in different contexts (e.g. legislation or conventions, such as the Helsinki or Stockholm Convention). Corporate instruments may exist for managing these substances as well, such as the "Global Automotive Declarable Substance List"⁶ of the automotive industry. Legislation, conventions and private instruments may contain lists of substances to which they refer. If substances are included in any of these lists, it is a strong indication that it is not sustainable.

Unfortunately, there is not "the one and only", but several lists exist. For the evaluation of sustainability of substances we recommend to use the following lists. They origin from European or international regulations and conventions. They have been thoroughly discussed by experts and politically agreed.

- › The candidate list for authorisation under REACH,
- › The list of priority and priority hazardous substances of the Water Framework Directive
- › Persistent organic compounds regulated under the POPs-Convention
- › Substances on the priority lists of OSPAR⁷ and HELCOM⁸
- › Substances affecting the climate according to the Montreal- and Kyoto -Protocol
- › Ozone depleting substances according to the Montreal protocol
- › Substances, for which marketing and use restrictions exist (REACH Annex XVII)
- › List of endocrine disrupting substances.

Substances are not mentioned here if they are discussed in the following chapters.

Relevance

- › *For society*: Toxicity – public health and integrity of workers
- › *For the environment*: Ecotoxicity – Health of ecosystems

Applicability of criterion

The criterion is applicable to any substance. The use of these lists should be easy as soon as the CAS numbers of the substances have been identified. If mixtures are assessed, each (known) component in the mixture should be checked if it is listed.

Information basis

The recommended lists are publicly accessible. As some of them are regularly updated, no current summary of the lists is provided. Links to the web pages are compiled in Annex 1.

Evaluation

Substances are only included in lists of problematic substances, if they have been assessed by experts as of particular concern. It is to be noted that the lists are developed for a particular purpose (e.g. environmental protection) or from a particular perspective. Therefore, certain properties may dominate whether or not a substance is included and consequently, the lists are not complete regarding sustainable decisions.

The criterion "mentioning on lists of problematic substance" is evaluated using Table. "Red" and "yellow" are not differentiated, because a substance can only be "listed" (=red) or "not listed" (=green).

TABLE 1: USE AND EVALUATION OF THE CRITERION "MENTIONING ON SUBSTANCE LISTS"

EVALUATION	RED	GREEN
Criterion Substance	Substance is mentioned in one or more lists.	Substance is not mentioned in any list.
Indicator	Substance lists (c.f. Annex 1).	

Note: "White" should be given if the CAS number of the substance has not yet been identified. In this case it is not possible to check clearly whether the substance is on the lists.

2.1.2. Dangerous physico-chemical properties

Substances with hazardous physico-chemical properties are difficult to handle for workers. Alternatives with less dangerous physico-chemical properties should be used or risk management measures implemented at workplaces, in order to prevent exposure and potential danger to workers. In addition, physico-chemical properties could endanger installations (explosion, fire).

Relevance

- > *For society:* Chemical risks at work
- > *For the economy:* Costs for measures, risks to property

Applicability of criterion

Some substances are used especially because of their (dangerous) physico-chemical properties; in these cases the criterion is not applicable. For example, fireworks cannot be produced without the use of pyrophoric substances⁹.

Information basis

Physico-chemical properties can be evaluated using a substance's classification. The necessary information should become available through the implementati-

on of REACH, as a comprehensive data set is already required for substances manufactured or imported in amounts between 1 and 10 t/a¹⁰. Users of substances can find information in sections 2, 9 and 10 of the pertaining safety data sheets. Additionally, public databases can be used, such as the "common substance data pool" (Gemeinsamer Stoffdatenpool von Bund und Ländern¹¹) or the data base on classification and labelling¹². If there are doubts on this information, substance manufacturers should be consulted.

Evaluation

In Table 2 dangerous physico-chemical properties and indications of danger (R- und H-phrases) are assigned to categories.

Remark

Particle size belongs to the physico-chemical properties. Nanoscale materials can be released from their matrices during the waste phase. At present knowledge is limited about the fate and the hazardous properties of nanoscale materials in waste treatment plants. This refers especially to materials which are not easily degraded. Therefore, if possible such uses should be avoided.

TABLE 2: USE AND EVALUATION OF THE CRITERION "DANGEROUS PHYSICO-CHEMICAL PROPERTIES"****

Evaluation	RED	YELLOW	GREEN
Criterion: Dangerous physico-chemical properties	Substance is explosive, oxidising, very flammable or pyrophoric	Substance is flammable	Substance has no R-phrase or only R-phrases between R1 and R19
Indicator: C&L according to 67/548/EEC*	E; R2, R3 ¹³ O; R7, R8, R9 F+; R12, R17	F; R10, R11, R15	No R-phrase
Indicator: C&L according to CLP-regulation **	H200, 201, 202, 203, 205, 220, 221, 222, 224-226) ¹⁴ , 228, 240, 241, 242, 250, 251, 260, 261, 270, 271	H 204, 221, 223, 224-226 ¹³ , 252, 272, 280, 281, 290	No R-phrase

Note: If information is missing to judge on this criterion, the colour white should be assigned. This indicates that information should be gathered.

*: C&L according to 67/548/EEC, Classification and labelling according to Directive 67/548/EEC

** : C&L according to CLP-regulation: Classification and labelling of substances according to the European regulation on the classification, labelling and packaging of substances and mixtures.

***In addition to Table 2::

Some R-phrases can be assigned only in addition to other classifications according to the "old" classification and labelling rules (complementary labelling). The CLP-regulation allows the independent assignment of these. If one or more of the R- or H-phrases apply, a substance's dangerousness is increased in the evaluation:

R1: Explosive when dry - EUH001

R6: Explosive with or without contact with air- EUH006

R14: Reacts violently with water - EUH014

R18: In use, may form flammable/explosive vapour-air mixture - EUH018

R19: May form explosive peroxides - EUH019

2.1.3. Human toxicity

Substances which are toxic to human health are to be avoided in general, because they may cause harm to workers during handling and use as well as to consumers during the use of chemical products or articles. The substance properties, which may cause irreversible and severe damage to human health, like cancer or which may damage the immune system, are more problematic than those which cause reversible and less severe effects. Some properties are relevant not only for human health, but also for adverse impacts they may have on the environment (e.g. endocrine disruption).

Relevance

> *For society:* Workers health and public health

Applicability of criterion

The human toxicity of a substance is an intrinsic property which can be viewed upon separately. However; the dangerousness to human health depends on the type of use of the substance and its mobility and emission potential (c.f. Chapter 2.1.5. and Chapter 2.2.1). If a substance is manufactured and used only under strictly controlled conditions (e.g. biocides to avoid bacterial contamination of closed cooling circuits or lead sulphate in car batteries), toxic effects to humans cannot be excluded, but are unlikely.

For certain applications, substances are selected just because of their dangerous properties, e.g. active substances in biocidal products and plant protection products, as well as pharmaceuticals. Here, the criterion cannot be applied. However, the use of such substances should be critically reviewed.

Information basis

The classification of a substance is normally sufficient for the evaluation. Respective information can be found in the safety data sheet (c.f. Annex 5) in sections 2 and 11. Regarding endocrine disruption, lists can be used, which have been developed in the context with the European strategy on endocrine disrupting substances (c.f. Annex 1).

Evaluation

In tables 3 and 4 the indications of danger (R-phrases) are assigned to categories (red, yellow, green). This assignment has been derived from the “Easy-to-use workplace control scheme for hazardous substances” (Einfaches Maßnahmenkonzept Gefahrstoffe, EMKG) of the Federal Agency for Occupational Health and Safety. It supports enterprises’ decisions on risk management measures to ensure safe use of substances and mixtures.

TABLE 3: USE AND EVALUATION OF THE CRITERION “HUMAN TOXICITY” ¹⁵ – DIRECTIVE 67/548/EEC			
Evaluation	RED	YELLOW	GREEN
Sub-criterion: Dangerous by inhalation, ingestion & eye contact	Substance may cause severe health damage	Substance may damage health	Substance is not dangerous to human health
Indicator Classification according to 67/548/EEC	R26, 28, 32, 39/26, 39/28, 45, 46, 48/23, 48/25, 49, 60, 61, 64	R20, 22, 23, 25, 29, 31, 39/23, 39/25, 40, 41, 42, 48/20, 48/22, 62, 63, 68, 68/20, 68/22	No classification “only” R36, 37, 65, 67
Sub-criterion: Dangerous upon skin contact	Substance may cause health damage if taken up via the skin	Substance damages skin	Substance has only light effects on skin
Indicator Classification according to 67/548/EEC	R35, R43 as well as R24 AND R27, 34, 39/27 For skin-penetrating substances ¹⁶ : R61	R21, 24, 34, 38, 39/24, 40, 48/21, 48/24, 68/21 For skin-penetrating substances ¹⁶ : R62, 63, 68	No classification “only” R66
Sub-criterion: Endocrine disruption	Substance is on the list of endocrine disrupting substances	Substance is a suspected endocrine disrupter	There is evidence that the substance is not endocrine disrupting
Indicator Substance list	Annex 1: links to substance lists (Endocrine Disrupting Chemicals, EDCs)	Substance is listed as suspected EDC, test results are ambiguous	Tests show the substance is not endocrine disrupting
Overall evaluation			

Note: If information is missing to judge on this criterion, the colour white should be assigned. This indicates that information should be gathered.

TABLE 4: USE AND EVALUATION OF THE CRITERION "HUMAN TOXICITY"¹⁷- CLP-REGULATION

Evaluation	RED	YELLOW	GREEN
Sub-criterion: Dangerous by inhalation, ingestion and eye contact	Substance may cause severe health damage	Substance may damage health	Substance is not dangerous to human health
Indicator: Classification according to CLP-regulation	H300, 330, 340, 350, 350i, 360D, 360F, 370 ¹⁸ , 372, EUH032, H 362	H 301, 302, 318, 330, 331, 332, 334, 341, 351, 361d, 361f, 371, 370, 372, 373 EUH029, EUH031	No classification "only" H304 319, 335, 336
Sub-criterion: Dangerous upon skin contact	Substance may cause health damage if taken up via the skin	Substance damages skin	Substance has only light effects on skin
Indicator: Classification according to CLP-regulation	H314 ¹⁹ , 317 as well as H311 AND H310, 370 ¹⁸ For skin-penetrating substances ²⁰ : H 360D	H311, 312, 314 ¹⁹ , 315, 370 ¹⁸ , 371, 373, For skin-penetrating substances 16: H 341, 361f, 361d	No classification "only" EUH066
Gesamtbewertung			

Note: If information is missing to judge on this criterion, the colour white should be assigned. This indicates that information should be gathered.

Remark:

If workplace exposure estimations have to be made for the use of substances, appropriate estimation tools should be used, e.g. the EMKG tool or the COSHH approach. The EMKG tool has been updated in September 2009. The new version includes the classification scheme according to the CLP regulation (BAUA 2009).

2.1.4. Problematic properties related to the environment

Substances, which are persistent, bioaccumulative and toxic (PBTs) or very persistent and very bioaccumulative (vPvBs) are particularly relevant for the environment, because they:

- › Concentrate in the environment (persistence and bioaccumulation) and in the long run may reach concentrations above which adverse effects are likely to occur,
- › Are transported via the atmosphere and biosphere and can be found far from their emission sources, even in pristine areas,;
- › Cannot be recovered, once they have been released to the environment.

Furthermore, PBTs and vPvBs can accumulate in the food chain and damage human health.

Beside PBT and vPvB substances, further substances are problematic for the environment, if they have the potential to harm the environment on a local scale – or in case of poorly degradable substances – on a larger scale. As criterion for these properties classification of substances as "harmful for the environment" is used.

Relevance

- › *For the environment and economy:* Damage to ecosystems
- › *For society:* Danger for human health via accumulation in the food chain

Applicability of criterion

For some substances and mixtures persistency and high aquatic toxicity are required for the function of the product. Examples are biocidal products which are harmful for the environment. In these cases the criterion always indicates a low degree of sustainability. In addition, the PBT/vPvB criterion is not applicable for elements because they can not be degraded.

Information basis

Substances which have been registered under REACH and exhibit PBT/vPvB properties have to be identified in the safety data sheet. Furthermore, information on persistence, degradation, bioaccumulation and aquatic toxicity have to be provided in sections 9 and 11 of the SDS. Data will increasingly become available in the context of registrations under REACH²¹.

Evaluation

In table 5 dangers for the environment are assigned to categories (red, yellow, green). For the evaluation of PBTs/vPvBs, the criteria of REACH Annex XIII are provided (c.f. Annex 2). If all criteria are fulfilled, the substance is a PBT/vPvB.

Frequently, information on half-lives and on bioconcentration is not available. If there is a lack of data, estima-

tions can be performed using indicative criteria on the degradability of a substance or its partitioning coefficient for octanol/water (LogK_{ow}): Substances which are inherently not degradable or are not easily degradable (OECD screening test²²) should be evaluated as persistent. Substances with a $\text{LogK}_{ow} > 4$ should be evaluated as bioaccumulative. It should be noted that these values are only indications of dangerousness and not sufficient for a classification as PBT or vPvB.

Substances classified as dangerous for the environment can have the following R phrases resp. H classes: R50 (H400), R51²³, R52²³, R50/53 (H400, H410).

TABLE 5: USE AND EVALUATION OF THE CRITERION "DANGEROUS FOR THE ENVIRONMENT"			
Evaluation	RED	YELLOW	GREEN
Criterion: PBT/vPvB and toxicity, data availability	Substance fulfils the PBT/vPvB criteria ²⁴ ; Information in SDB, that substance is a PBT/vPvB is	Based on available information, it cannot be excluded that the substance is a PBT/vPvB. t^{25} . LC_{50} value.	No PBT/vPvB, Low aquatic toxicity.
Indicator Substance information from testing	Data on persistence and bioaccumulation, toxicity and ecotoxicity. Substance is identified as PBT/vPvB (candidate list)	PBT/vPvB Aquatische Toxizität: $\text{LC}_{50} < 0,1 \text{ mg/l}$. R50, R51, R52 H400	There is evidence that the substance is not a PBT/vPvB and has no or a very low aquatic toxicity Substances not classified as dangerous for the environment

Note: If information is missing to judge on this criterion, the colour white should be assigned. This indicates that information should be gathered.

2.1.5. Mobility

Substances which are very mobile in air and water have the potential to disperse in the working and natural environment as well as in the consumer environment. Therefore, mobile substances indicate a high likelihood of exposures of different subjects of protection. However, a high mobility is only critical if substances also have a high human or environmental toxicity. Furthermore, high mobility may lead to high substance losses (resource efficiency).

A substance's mobility is determined by its properties and its use (c.f. Chapter 2.2.1). In this chapter, only substance properties influencing partitioning and distribution in air and water, as well as the potential to penetrate the skin are discussed. The latter is relevant because if a substance cannot penetrate the skin, dermal exposure is less problematic.

Relevance:

- › For society: Emissions at workplaces and in the consumer environment
- › For the environment: Emissions of pollutants
- › For the economy: Losses of substances during use

Applicability of criterion

Substances used in applications requiring a high mobility (e.g. solvents in printing inks, which have to dry quickly to ensure smooth printing processes) can be evaluated with the criterion only to a limited extent. The relevance of the criterion is to always be decided on in relation to the use of a substance.

Information basis

Information on the mobility of a substance can be found in the safety data sheet in section 9 (partly also sections 2 and 11). Furthermore, public data bases can be consulted.

Evaluation

In table 6 mobility is assigned to categories (red, yellow, green). To evaluate the mobility, all subcriteria should be checked and then summarized in the overall evaluation (note: not all criteria are applicable to all substances). The sub-criterion with the most severe evaluation represents the overall evaluation.

Note: A high mobility is relevant only if the substance is dangerous for man or the environment or if it causes high losses of the substance. The latter would lead to a decrease in resource efficiency.

TABLE 6: USE AND EVALUATION OF THE CRITERION “MOBILITY”

Evaluation	RED	YELLOW	GREEN
Sub-criterion: Release potential in water	High solubility	Medium solubility	Low solubility
Indicator Solubility in water	> 10 mg/l	10 – 0,001 mg/l	< 1 ↔g /l
Sub-criterion: Release potential to air	High vapour pressure	Medium vapour pressure	Low vapour pressure
Indicator Vapour pressure	10-3 to 100 Pa (Environment) > 25 Pa (Humans)	10-3 - 10 -8 Pa (Environment) 0.5 – 25 Pa (Humans)	< 10 -8 Pa (Environment) < 0.5 Pa (Humans)
Sub-criterion: Long-range transport	Substance is transported over long distances	Indications on persistence and transport	No long-range transport
Indicator: Persistence, indications on long-range transport	Substance is persistent (half-life in air > 2 days), vapour pressure < 1 hPa or substance is found in pristine environments.	Indications or suspicion of longrange transport	There is evidence that the substance is not transported over long distances, not persistent
Sub-criterion Release potential at workplaces	Very dusty	Dusty	Not dusty
Indicator Dosage form of manufacturer	Aerosols & gases, substance which form clouds of dusts, which remain in the air for a longer time	Substance which are pulverised but not too dusty, dust deposits quickly.	Liquids, non-dusty solid substances (Pellets, waxes, granulates...)
Sub-criterion General release potential	Use in mixtures, or intended release form articles	Is released unintentionally from articles	Firm embedding in matrix or containment inside articles
The following sub-criteria are not relevant for manufacturers of substances			
Indicator: Release (migration), Integration in product matrices	Use in mixtures. Substance is contained in articles, from which it is intended to be released	Substance is not used in mixtures and it is not known that it is released from the matrix during the lifecycle of the product.	Embedding of substance in matrix or containment in inside product, no use in mixtures
Overall evaluation			

Note: If information is missing to judge on this criterion, the colour white should be assigned. This indicates that information should be gathered.

Note: A high mobility is relevant only if the substance is dangerous for man or the environment or if it causes high losses of the substance. The latter would lead to a decrease in resource efficiency.

2.1.6. Origin of raw materials

This criterion addresses the environmental and social responsibility taken by the suppliers. If the quality of raw materials is the same, normally the price is decisive for the choice of suppliers. If raw materials are selected according to their sustainability, the conditions of environmental protection and workplace health and safety should be considered for their manufacture and in the purchasing decision. The standards on environmental and workers protection (safety and health at the workplace, fair pay etc.) can be very different across the

world. However, big differences may also exist between enterprises located in the same region.

Relevance

- > *For the environment:* Damage at the location of raw materials production
- > *For society:* Conditions at workplaces and social standards
- > *For the economy:* Costs of raw materials, support for enterprises and regions which produce sustainably

Applicability of criterion

Taking responsibility for the environment and social conditions should be evaluated, first for suppliers from which high amounts of raw materials are obtained. Suppliers, for which little information is available, could also be evaluated.

Information basis

To evaluate whether or not suppliers feel responsible for environmental protection and agreeable social conditions not only within, but also in the nearer context of their companies, information on the suppliers themselves is to be obtained. Information sources could be statements on corporate policies or sustainability and environmental reports in the context of certified management systems (workers protection: BA 18000; quality: ISO 9000; environment: ISO 14000 or EMAS). Furthermore, the willingness to provide information, the overall service and

the quality of chemicals supplied can be used as criteria, as well as the existence of “Codes of Conduct”, requiring compliance with social standards. The engagement in social projects (social sponsoring, specific projects for the environment or on sustainability, research) may also be assessed. In principle, information reviewed by independent auditors should be weighted higher than that which is “purely voluntary”.

Evaluation

In table 7 origins of raw materials are assigned to categories (red, yellow, green). The higher the commitment to comply with protection standards at workplaces and for the environment, the more responsible and hence sustainable a supplier is. The borderline cannot be “objective” but if several suppliers are evaluated they could be ranked or assigned to relative categories of sustainability.

TABLE 7: USE AND EVALUATION OF THE CRITERION “ORIGIN OF RAW MATERIALS”			
Evaluation	RED	YELLOW	GREEN
Sub-criterion: Responsibility for workplaces	The supplier doesn't care about workers protection.	Supplier complies with legal requirements on workers protection	Supplier values workers protection very high
Indicator Management system, risk management at work	No management system is mentioned in the company policy, workers protection is not an issue	Quality control and workers protection measures are implemented, no independent auditing	Good (documented) management system (e.g. BA 18.000), implementation of standards, voluntary measures (independent audits, certification) Umweltschutz ist nachweislich wichtig für den Lieferanten.
Sub-criterion: Responsibility for the environment	Supplier doesn't care about environmental protection	There are indications that environmental legislation is complied with.	Environmental protection is very important to the supplier
Indicator Management system, emission reduction etc.	No management systems and environmental protection goals in the company policy	Environmental management system (EMAS, ISO 14,000) exists; standards implemented, no independent auditing	Good (documented) management system (EMAS, ISO 14,000 product labels etc.), standards implemented, independent audit / certification
Sub-criterion: Social responsibility	No involvement in social activities in and outside company	There are indications that social standards are important to the supplier.	Improvement of social conditions is important to the supplier
Indicator Social activities and goals	No information on social activities, no training and education in company	Supplier is involved in social projects outside the company	Supplier has “Code of Conduct”, is social sponsor and provides training in the company.
Total evaluation			

Note: If information is missing to judge on this criterion, the colour white should be assigned. This indicates that information should be gathered.

2.1.7. Emission of greenhouse gases due to manufacture of raw materials or of the substance itself

The effects of a substance on the global climate can be measured by the emission of greenhouse gases caused for its production²⁶. This regards emissions in the upstream chain – for obtaining raw materials - and the substance manufacture itself. The basis for evaluation is the calculated amount of CO₂-equivalents. This amount is normally dominated by the energy consumption and transports for obtaining raw materials. Therefore, the criterion is frequently correlated with the resource consumption (c.f. Chapter 2.1.8).

Relevance

- › *For the environment:* Anthropogenic greenhouse effect
- › *For society:* Climate change and its consequences
- › *For the economy:* Costs of climate change

Applicability of criterion

The absolute values of CO₂-equivalents emitted along the lifecycle of a substance normally have a low expressiveness. The evaluation is more meaningful, if done in a comparative manner. The amounts of the substance needed in order to fulfil a certain function should be used as point of reference, rather than a total amount

of a substance. The amount of CO₂-equivalents identified as being emitted for the production of 1 kg of a substance is to be multiplied with the amount needed to perform the function, in order to compare alternatives. This approach allows to compare alternative solutions which differ in the amount of substances they need.

If substances manufactured from the same or similar raw materials are compared, the criterion greenhouse potential is frequently not selective enough due to lack of specific data for specific substances.

Information basis

Information on the greenhouse gas emissions caused by the manufacture of a substance can be found, for example in the data base Probas of the German Environment Agency (c.f. Annex 3). If the substance under evaluation is not contained in the data base, it may be possible to select a substance which is produced in a similar manner (similar raw materials, similar processing techniques). The compilation of a greenhouse gas balance for a substance is highly acknowledgeable, but very time and resource consuming.



EXCURSUS:

Meanwhile, producers of some products (e.g. construction materials) develop environmental product declarations (EPD). These consist of a product-specific greenhouse gas balance, among others. Such environmental product declarations would enable users of chemicals to reliably compare greenhouse gas emissions. In 2009, the international chemicals association (ICCA) published eco balances of selected chemicals (ICCA 2009)²⁷.



Evaluation

The criterion greenhouse potential is measured in CO₂-equivalents emitted for the production of a substance. As first step, it should be assessed what amount (in kilogram) of a substance is necessary for a respective use. Only then can a comparative assessment be performed.

The approach to evaluate greenhouse gas emissions proposed in this guide assumes the following:

On average, 5 kg CO₂-equivalents are released if 1 kg of an anorganic or organic substance is produced. For a first estimation the following advice can be given: releases of greenhouse gases will be less relevant for a substance if they amount to approximately 1/5 of this value. Therefore a value of 1 kg CO₂-equivalents/ kg substance is given in the following table. However, if very high amounts of a substance are used, even low greenhouse gas emissions per kilogram may result in a high total amount. Here, possibilities should be checked to reduce emissions of greenhouse gases - including the assessment of the benefits of a use (c.f. Chapter 2.2.6).

The values provided in table 8 are first indicators for the evaluation, referring to information from the life cycle assessment data base PROBAS (see annex 3). For more comprehensive statements, a comparative case-by-case assessment is necessary, which does not relate to a fixed amount of the substance (1 kg), but to the amount necessary to fulfil the desired function.

2.1.8. Resource consumption for the manufacture of raw materials and the substance

For the manufacture of substances²⁸ raw materials, water and energy are consumed²⁹. The high resource consumptions for the manufacture of substances can be an indication of low sustainability. This is true, for example if comparable alternatives are available, for which less resources are consumed.

The evaluation of the resource consumption for the manufacture of a substance requires considering the upstream chains of a raw material or substance. This is in particular:

- > obtaining raw materials (e.g. extraction and transport of mineral oil, excavation and transport of minerals or metal ores, cultivation of renewable resources),
- > refining of raw materials (purification) as well as
- > chemical synthesis

The type of raw materials reflects another aspect of sustainability (fossil raw materials, renewable, etc.). Furthermore, the amount of waste produced per amount of manufactured substance (including waste from upstream chains) is an indicator of resource efficiency.

Relevance

- > *For the environment:* Consumption of resources
- > *For society:* Use of resources of future generations
- > *For the economy:* Cost reduction if resource efficiency is increased

The identification of specific data on resource consumptions (including upstream chains) requires a comprehensive analysis of processing steps and uses of materials, which is normally too extensive to perform in addition to every day company work. Therefore, in this guide a simplified approach and set of criteria is proposed that is sufficient for a first, qualitative evaluation.

TABLE 8: USE AND EVALUATION OF THE CRITERION "GREENHOUSE GAS POTENTIAL"			
Evaluation	RED	YELLOW	GREEN
Criterion: Greenhouse potential	High emissions of greenhouse gases	Medium emissions of greenhouse gases	Low emissions of greenhouse gases
Indicator Aggregated greenhouse gas emissions as CO ₂ -equivalents / kg substance	> 50	1 - 50	< 1

In any case a comparative case-by-case assessment considering the functional unit is necessary.

Note: If information is missing to judge on this criterion, the colour white should be assigned. This indicates that information should be gathered.

Applicability of the criterion

The absolute values of the consumption of energy, raw materials and water, as well as the quotient of the amounts of waste per manufactured product are normally not very expressive. Only the comparison of two alternatives results in selective judgements regarding the resource efficiency of a substance.

The following table provides as a rough indication some benchmarks to distinguish “high”, “medium” and “low” relevance of the criterion. The figures are based on information from the data base PROBAS. If a substance is used in high amounts, the criterion should be taken into account anyway.

Evaluation – first categorisation

The following table outlines rough categories related to the manufacture of substances and the consumed resources: metals, minerals, bulk materials from minerals, substances made from mineral oil, substances made from biological materials and wastes.



Even renewable resources such as cotton and packaging made from maize meal starch can have a bad LCA.



EXCURSUS:

Also renewable resources can be non-sustainable if their cultivation is connected to high resource consumptions, e.g. in form of fertilisers and pesticides. Their cultivation could compete with other land uses, e.g.

the production of food or require high water consumptions (e.g. cotton). Packaging made of corn starch is an example of a product that has been negatively assessed in lifecycle analyses (high energy and material consumption).

Chapter 4.1 of the background paper of the German Environment Agency on sustainable chemistry³⁰, describes more in detail sustainability aspects of renewable raw materials. In Germany two sustainability regulations exist referring to different kinds of bio fuels. They contain specific criteria for sustainability, e.g. protection of areas with high value for nature protection, protection of peat bog, sustainable agricultural use and greenhouse gas emission reduction potential (BGB 2009).

Substances for which low resource consumption has been identified can be used inefficiently and therefore also non-sustainably. According to the Rio-declaration³¹, renewable resources should be consumed only to the extent they regenerate. A translation of this principle into company practice means to check if the global consumption of a specific raw material exceeds the regenerated amount. Indicators for excessive use can be declines of respective “populations” or stocks, increased prices due to scarcity or literature reviewing the use and cultivation of renewable resources.

TABLE 9: USE AND EVALUATION OF THE CRITERION "USE OF RESOURCES"

Evaluation	RED	YELLOW	GREEN
Sub-criterion: Renewability of resources	Non-renewable and scarce raw materials	Non-renewable raw materials available in large amounts. Renewable resources used in excess or produced with high resource consumption	Renewable raw materials used below the amount that is regenerated, wastes
Indicator Type of raw material - preliminary evaluation	E.g. fossil raw materials the stocks of which are limited. Raw materials which are difficult to reach (e.g. underground mining, deep drilling, high efforts for purification, etc.), e.g. beryllium	Non-scarce fossil raw materials (some minerals and gases) which can be obtained with comparably low efforts (surface mining, low refinement efforts) e.g. Iron	Sustainably used raw materials, recovered substances from wastes e.g. gelatine
Renewable raw materials (origin: plants or animals) can be yellow or green			
A case-by-case assessment is necessary			
Sub-criterion: Energy consumption	High energy consumption	Medium energy consumption	Low energy consumption
Indicator Type of raw material - preliminary evaluation	Some metals, some minerals	Some mineral bulk materials, substances from mineral oil and natural gas	Some substances of biological origin, substances recovered from wastes
Renewable raw materials (origin: plants or animals) can be yellow or green			
A case-by-case assessment is necessary			
Sub-criterion: Water consumption	High water consumption	Medium water consumption	Low water consumption
Indicator Type of raw material - preliminary evaluation	Some metals, some minerals	Some mineral substances, substances from wastes	Some substances of biological origin, substances made of mineral oil
A case-by-case assessment is necessary Note: The criterion might be less relevant if water consumption is below 5 l/ kg substance. It might be highly relevant if water consumption is above 100 l/kg substance.			
Sub-criterion: Amount of waste	High quotient of waste per product	Medium quotient of waste per product	Low quotient of waste per product
Indicator Type of raw material - preliminary evaluation	Some metals, some minerals	Some mineral bulk substances, substances from mineral oil and natural gas	Some substances of biological origin, substances from wastes
A case-by-case assessment is necessary Note: The criterion might be less relevant if amount of waste is below 1 kg/ kg substance. It might be highly relevant if amount of waste is above 50 kg/kg substance.			
Total evaluation			

Note: If information is missing to judge on this criterion, the colour white should be assigned. This indicates that information should be gathered.

Remark: The waste phase and the possibility to recycle materials from waste streams are of high importance for the sustainability of a substance. See chapter 2.2.4 for details.

Evaluation – Indications for a more detailed assessment

The above listed criteria can also be used to compare substances in detail, (type of raw material, consumption of energy and water, amount of waste). Respective data have been compiled in the context of lifecycle analyses (LCA) and other methods for the assessment of materials and processes. However, they are of course not available for all substances.

In Annex 3, data bases are listed which may be helpful for a detailed evaluation. If two substances are compared it is important that the same methods and data bases are used for both substances.

The differences within the above categories can be identified more clearly in a detailed evaluation. Since such evaluations can be very time consuming, they should only be started if it has been determined that the resource consumption is decisive for the evaluation of the sustainability of a substance.

2.1.9. Summary of evaluation

This guidance does not intend to lead to a one-number sustainability assessment. It is possible to sum up the results of the single criteria in a number. However this could lead to a loss of information – instead of using the results of the single criteria.

Therefore we do not propose a final evaluation for a substance with one colour covering all criteria (see also chapter 1.6 of this guidance). The results of the single criteria should be used for improvements regarding different aspects of sustainability – for one substance and his life cycle or for a comparison between two or more substances.

In table 10, the substance-specific criteria are summarised. This table should be filled in separately for each substance that is evaluated. If a mixture is evaluated, the results for the mixture could be filled in or, if only components of the mixture are evaluated, one table for each component should be filled. The result is a sustainability profile of the substance or the mixture, respectively.



EXCURSUS:

As already mentioned in the previous chapter, for some products of different sectors, environmental product declarations (EPD) are available. The product related analysis includes an inventory of environmental indicators, among other the consumption of energy and the generation of wastes. Such environmental product declarations could enable users of substances and mixtures to make a comparative assessment based on sound data on resource consumption for the manufacture of substances.

TABLE 10: SUSTAINABILITY PROFILE FOR A SUBSTANCE

Substance-specific criteria	RED	WHITE	YELLOW	GREEN
Mentioning on substance lists				
Physico-chemical properties				
Human toxicity				
Dangerousness for the environment				
Mobility				
Origin of substance: Environmental and social standards				
Greenhouse potential including upstream chains				
Resource consumption including upstream chains				

In Chapter 4 this profile is illustrated for two example substances.

2.2. USE-SPECIFIC CRITERIA FOR THE EVALUATION OF SUSTAINABILITY

The use-specific criteria for the evaluation of the sustainability of a substance or mixture should be used to better value or weight the results of the evaluation of substance-specific criteria. The use-specific criteria are described in more a qualitative way, compared to the substance-specific criteria, because due to the high variety of uses of substances and mixtures, no structure can be defined that includes the majority of cases and no generally applicable and unambiguous indicators can be defined. This chapter therefore supports the reflection of the results of the first evaluation steps.

The results of the application of the substance-specific criteria should be used in the following way:

- › A need for action due to substances on lists, dangerous physico-chemical properties and origin of raw materials (criteria 1,2 and 6) is independent from the use-specific criteria;
- › For substances with dangerous properties regarding man and the environment (criteria 3 and 4) the use-specific criteria should be checked in any case;
- › For the substance-specific criteria “Greenhouse gas emissions” and “Use of resources” (criteria 7 and 8) especially the use-specific criteria “Emission potential” and “Use amount” are important;
- › The use-specific criteria “substitution potential”, “benefits potential” and “innovation potential” can modify (enhance / decrease) the weight of the substance-specific criteria “Substance on list”, “Dangerous physico-chemical properties”, “Human Toxicity”, “Problematic properties regarding the environment”, “Mobility”, “Use of resources” and “Greenhouse potential”

For substance manufacturers, formulators and users of substances and mixtures, which have come to the conclusion to substitute a chemical because of its sustainability profile, this chapter can still be helpful in focusing the search for alternatives.

To evaluate the sustainability of chemicals, in this second step, seven criteria are proposed that relate to the use:

1. The emission potential
2. The user groups
3. The used amounts
4. The waste stage
5. The substitution alternatives
6. The benefits of a chemical / its use
7. The innovation potential of a chemical / its use

In the following chapters these seven criteria are described. Main points are the meaning of the criteria, the applicability, the information basis, the relevance related to the substance-specific criteria and the evaluation.

2.2.1. Emission potential of the use of a substance or mixture³²

In this guide, the “emission potential of a use” is understood as an estimation of the amounts of a substance (as such or contained in mixtures or articles) which are released along its lifecycle. The releases could occur from industrial installations to the environment, to the workplaces or from products into the living environment. These releases normally result in a contact with man or the environment (exposure) and potentially may cause damage.

Substances are not sustainable if they exhibit problematic substance properties and if they are released during their use, which may finally cause adverse effects in man and the environment. If substances are of very high concern, low releases can already be critical.

Furthermore, a high emission potential is equal to high losses of the substance indicating an inefficient use of resources. Therefore this criterion is relevant in relation to the resource consumption as well.

The criterion “emission potential of use” is to be related to the criteria “user groups” (Chapter 2.2.2) and “mobility” (Chapter 2.1.5) because the emission potential depends among others on how mobile a substance is and whether or not it is used in a correct manner.

The explanation and support of a comprehensive assessment of emissions along the lifecycle of a substance is not possible in this guide. Publications on this topic can be found on the web in much detail, for example:

- › The VCI REACH Practical Guide on Exposure Assessment and Communication in the Supply Chains introduces to the topics exposure assessment and communication in the supply chain with several recommendations on the implementation in practice³³.
- › The guidance document of the European Chemicals Agency (ECHA) on information requirements and chemical safety assessment describes a method for assessing exposures and characterizing risks from the use of chemicals³⁴

The emission potential should be estimated for the entire lifecycle of a substance, which means that also emissions at the customers, which use the products are to be considered.



Substance manufacturers, which have to assess the safety of a substance in the frame of a REACH registration, should use that information in the evaluation of sustainability. Important information for the evaluation of sustainability is e.g. if a high degree of risk management is necessary to ensure safe handling and use of a chemical or if certain uses are not safe.

Emissions at the workplace³⁵ could result from evaporation, dusting or skin contact of the chemical and the worker. The degree of release depends on the type of processing and the conditions of use. Emissions into the living environment of consumers may result from the use of chemical mixtures (e.g. air fresheners, paints) through the formation of aerosols, evaporation or dusting or e.g. through the use in water (dish washing agent). Furthermore, articles may release substances (e.g. plasticisers in PVC-flooring).

The environmental emission potential equals to the sum of all emissions of the substance from mixtures and articles, which are released to the environment via the air, water or soil.

Relevance related to the substance-specific criteria

A high emission equals a high loss of substance. This is an ineffective use of resources. Therefore the criterion “Emission potential” is relevant for the criterion “Resource consumption” (chapter 2.1.8). The criterion “Emission potential” has to be seen together with the criterion “User groups” (chapter 2.2.2) and the criterion

“Mobility” (chapter 2.1.5), because the emission of a substance depends on its mobility and the way of handling the substance.

Applicability of the criterion

The criterion can be applied to any type of substance (as such or as component of a mixture or article). The criterion is not very expressive for substances which are only used as intermediates, as their lifecycle is very short and normally strictly controlled. The lifecycle of substances used as processing aids normally ends with their actual use inside a mixture (they are not included in any articles), but includes the waste phase of product residues.

Information basis

Information on the use of a substance as such or in mixtures and articles are either available (purpose of product) or have to be requested from the users (communication with customers).

Evaluation

In tables 11, 12 and 13, examples of uses with very high and very low emission potentials are given. In the first table this is related to the substance-specific criteria “dangerous for the environment” and “resource consumption”. In the second table it is related to the “dangerousness for the worker” and in the third to the “dangerousness for the consumer”, the latter two being a more differentiated view on the “human toxicity”.

The high emission potentials can enhance the importance of the evaluation of the substance-specific criteria (dangerous for man and the environment, resource consumption, i.e. yellow > red) and low emission potentials can attenuate them (red > yellow).

TABLE 11: INDICATORS FOR THE EVALUATION OF THE EMISSION POTENTIAL OF USES RELATED TO THE ENVIRONMENT³⁶

INFLUENCING FACTORS	CRITICAL USES, HIGH EMISSION POTENTIAL	LESS CRITICAL USES, LOW EMISSION POTENTIAL
Use of the substance as such or in mixtures	Open use in the environment, in private households in crafts, use in SMEs+	Chemical synthesis; use in large installations, automated processes
Relevance of use regarding water emissions	Use in aqueous systems or in direct contact with environmental media	Substance or mixture does not come into contact with water
"Containment" of installation	Open or semi-open installation, wastewater and exhaust gas are generated	Substance or mixture is used in closed systems or installations ³⁷ .
Other conditions of use of substance or mixture	Processing at high temperatures and high pressures, mechanical stress (abrasion, formation of dusts)	Processing at room temperature or less, no extreme conditions
Disposal of production wastes or wastes from consumer mixtures	No specific disposal, consumers products disposed with wastewater or household waste	Disposal by destruction or systematic collection and recovery / recycling
State-of-the-Art of end-of-pipe technologies	Capture of emissions according to State-of-the-Art not ensured, all chemicals for consumers	Exhaust gas and wastewater are cleaned and disposed of according to legal requirements
Substance as part of articles	Flat products, coatings, outdoor use, abrasion	Compacted products, indoor use, no abrasion
Disposal of articles containing the substance	Wide dispersive use, no special collection or disposal system, normally part of household waste	Small group of users, specific waste regimes exist (e.g. electric devices, cars etc.)
Influence of mobility (water and air to be viewed upon separately)	Mobile substances or substances which don't react with article matrices	Substances with low mobility, substances which are firmly embedded in article matrices

TABLE 12: INDICATORS FOR THE EVALUATION OF THE EMISSION POTENTIAL OF USES RELATED TO THE WORKPLACE

INFLUENCING FACTORS	CRITICAL USES, HIGH EMISSION POTENTIAL	LESS CRITICAL USES, LOW EMISSION POTENTIAL
Use of the substance as such or in mixtures	Use in installations with low technical standards, professional use in crafts	Installations for chemical synthesis, installations with high technical standards (automated processes)
Type of use - dosage of substances and mixtures	Manual dosage of powders and liquids, direct feeding of dusty or volatile chemicals	Simple dosage (closed pipes, ready-to-use packaging), immobilization, e.g. by compounding
Type of use - processing	High energy or fast processes, low degree of automation. Open, manual use (e.g. spraying, cutting, immersion)	Automated processes, low energy or slow processing. Organisational or technical separation of worker and chemical
Disposal and cleaning	No separation of wastes; disposal is not regulated, cleaning and maintenance is conducted untrained personnel	Separate disposal through specified waste management company, cleaning and maintenance by expert companies (incl. abatement equipment)
State-of-the-Art of workers protection	No management system for workers health, few emission reduction measures, use by professional users, use at "mobile" workplaces	Existing management system for workers health, regular risk assessment at workplaces and emission reduction measures implemented.
Influence of mobility (volatility more important than solubility, Log Kow for dermal contact)	Mobile substances	Low mobility of substances

TABLE 13: INDICATORS FOR THE EVALUATION OF THE EMISSION POTENTIAL OF USES RELATED TO CONSUMERS

INFLUENCING FACTORS	CRITICAL USES, HIGH EMISSION POTENTIAL	LESS CRITICAL USES, LOW EMISSION POTENTIAL
Type of use of substance or mixture	Manual dosage of powders and liquids	Ready-to-use packaging, tabs, high viscous mixtures
Type of use application	Spray applications “open uses”, e.g. wiping, direct contact with skin and lungs	Use inside machines (e.g. washing), use in specific equipments (e.g. silicone cartridge guns), direct contact is low
Waste disposal	Complicated disposal (e.g. paints), cleaning of equipment necessary	Disposal without refilling or cleaning, no waste is generated
Substance as part of articles	Substance is not firmly embedded in article matrix, ca e.g. leach or evaporate during use	Substance is integrated in article matrix or inside closed sub-parts
Influence of mobility (water and air to be viewed upon separately)	Mobile substances or substances which are not firmly embedded in an article matrix	Substances with low mobility or which are firmly integrated in article matrices

Recommendation: Enterprises should create an overview which processes are characterised by specifically high substances’ releases. For these processes emission reduction potentials at workplaces or to the environment as well as improvements of product qualities (healthier products for consumers) and cost savings are very likely to be high. Hints on how to compile such an overview can be found in the REACH Practical Guide on Exposure Assessment and Communication in the Supply Chains³⁸.

2.2.2. User groups of a substance

Substances are used as such, in mixtures and as part of articles by different groups of persons and in different environments. For the evaluation it is important whether particularly vulnerable user groups handle the substance, such as children or handicapped people. In principle these groups, which require a higher degree of protection, should not be exposed to chemicals, which may cause harm to human health. In this case, not only the use of the substance in whatever form is relevant, but also if it is released³⁹ (c.f. Chapter 2.1.5 “mobility” and Chapter 2.2.1 “emission potential”).

Relevance related to substance-specific criteria

In relation to the user groups, only the criterion “human toxicity” is considered, although other criteria could also be relevant. If vulnerable user groups are identified, the evaluation results of the criterion human toxicity should be modified (yellow à red and even higher urgency for white).

Information basis

The uses of a substance need to be known as well as the user groups (consumers, vulnerable groups, workers) of the end product.

Evaluation

Vulnerable groups, such as children and pregnant women, should not come into contact with chemicals which are toxic to human health at all. Workers are often exposed to high amounts of substances and at higher frequencies. Consumers could be exposed to emissions of substances from products inside their homes.

In table 14, for each criterion it is assumed that a “yellow” evaluation has been concluded for the mobility of the substance in the first steps. Using the examples, it can be derived if the substance-specific characteristics are enforced or attenuated by the types of user groups.

TABLE 14: USE AND EVALUATION OF THE CRITERION "USER GROUPS"

SUBSTANCE-SPECIFIC CRITERIA	ENFORCEMENT	ATTENUATION
Substance is on lists of problematic substances	Use should be avoided for any user group	
Substance is dangerous to human health	Substance is used in products for children or for vulnerable groups. Substance is used indoors.	Substance as such and in mixtures is only foreseen for use by professional users. Substance is used only in consumer articles, which don't give rise to releases to indoor environments
Substance is volatile and dissolves well in water	Substance is used in consumer products and for indoor use. Substance is used in articles from which they are intentionally released (e.g. pens, fragrance candles)	Substance is only used in products for professional users

2.2.3. The use amount

There are no harmonized definitions of which amounts are a "high" or "low" amount. Under REACH, registration requirements distinguish between amounts of 1 to 10, 10 to 100, 100 to 1000 and above 1000 t/a. The amounts should be considered in relation to the dangerous properties: for a substance of very high concern (SVHC) an amount of 1 t/a may already be very high.

For articles containing SVHC the concentration limit of 0.1% (weight/weight) set in REACH Art. 7.2 is a reasonable order of magnitude. In Europe, a concentration above this limit triggers the legal requirement to make a notification to ECHA as described in REACH Art. 7.2.

In order to avoid non-sustainable impacts on man and the environment, in case of complex articles this concentration limit should refer to the homogeneous materials within the article. Especially the substance-specific criteria "Human toxicity" (chapter 2.1.3), "Problematic properties related to the environment" (chapter 2.1.4), "Mobility" (chapter 2.1.5), "Emission of greenhouse gases" (chapter 2.1.7) and "Resource consumption" have to be seen in connection with the amount used.

Relevance related to substance-specific criteria

High use amounts can enhance the importance of some substance-specific criteria. The higher the resource consumption or the emission of greenhouse gases for the production of a substance, the higher the weight of these criteria in the overall evaluation is. In particular if large amounts of the substance are produced or used. Vice versa, if a substance is used in small amounts, the importance of the criteria "resource consumption" and "greenhouse gas emissions" should be decreased.

Applicability of the criterion

The criterion can be applied to any substance or mixture. Manufacturers should relate to the substance amount they produce. Formulators could either assess amounts of a substance used in a mixture or the amount of the mixture as such. Users of mixtures can identify the use amount of a component by multiplying the concentration in the mixture with the total amount of the mixture used⁴⁰.

Information basis

The own manufactured or used amount (company information) or market volumes of the substance in the EU can be used.

Evaluation

The use amount as isolated indicator is fairly meaningless. Therefore, in table 15 the substance-specific criteria are used as basis for the assessment of use amounts. The high amounts enhance a negative evaluation of the substance-specific criteria and low amounts attenuate them.

Recommendation: Enterprises should in a first assessment use their substance inventory in order to get an overview of which of the critical substances are used in particularly high amounts.

TABLE 15: USE AND EVALUATION OF THE CRITERION “USE AMOUNTS”

SUBSTANCE-SPECIFIC CRITERION	SIGNIFICANCE OF AMOUNT AS INDICATOR
Substance is mentioned on lists of problematic substances	Independent of other criteria. The use should be phased out or at least use amounts should be minimized.
Dangerous PC-properties	Dangerous PC properties are mostly independent of used amounts
Substance is dangerous to human health	Workers > kg/day = high; mg/day = low. For CMR substances the exposure levels can be critical depending on the type of use even if only a few grams per day are applied. Substances in consumer products should be contained in concentrations below the classification limits (low amount). If substances are incorporated in articles critical amounts are difficult to evaluate and the criteria “emission potential” and “mobility” should be applied instead.
Substance is dangerous to the environment	Critical amounts depend on the degradability of the substance: for non or only slowly degradable substances, low volumes can already be critical. For easily degradable substances, this criterion should not be applied.
PBT/vPvB – substances	Any type of use should be avoided independent of the amount.
Mobility	The linking of mobility and use amounts is not meaningful.
Resource consumption	The higher the production or use amounts, the higher the resource consumption. Indication for “high” = more than 1,000 t/a
Greenhouse potential	The higher the production or use amounts, the higher the emission of greenhouse gases. Indication for “high” = more than 1,000 t/a
Origin of raw materials	The higher the use amount and the more expensive the substance, the higher the financial support for questionable production methods or social conditions. Indication for high: more than 1 tonne per year

2.2.4. Waste stage

Some substances may cause risks for man or the environment when they become waste. Generally, the recovery of substances from wastes should be aspired to save resources and energy. However, recycling could be problematic if substances contaminate a material stream and reach new products.

Sustainable substances should either fully degrade or mineralise during disposal (no waste in the long run) or be designed in a way that they can be fully recycled without loss in quality⁴¹. Although some indicators of potential problems during the waste phase exist, it should be assessed case-by-case whether or not they are relevant and if they change the overall evaluation a substance’s sustainability.

The final product, in which the substance is used, is of high significance in this assessment, as it normally determines the disposal pathways.

Relevance related to substance-specific criteria

If a substance or a product containing a substance becomes waste (because the substance is not completely degradable or is not recycled), the substance-specific criteria get more importance.

The evaluation of the waste phase can enhance the results of the criteria “Human toxicity” (chapter 2.1.3) and “Problematic properties related to the environment” (chapter 2.1.4), “mobility” (chapter 2.1.5) and “Resource consumption” (chapter 2.1.8), if indications of problems during the waste phase exist.

Applicability of the criterion

For substances which don’t occur in wastes, e.g. because they are almost fully emitted during their lifecycle (e.g. solvents) or because they react with other substances (intermediates, reactive additives) the criterion is not applicable.

Information basis

In order to assess the waste phase, the substance manufacturer or user has to identify the likely disposal pathways of the products (mixtures or articles in industrial, professional and consumer uses) the substance is used in and assess potential problems in relation to the substance properties.

Evaluation

The following list presents combinations of waste

treatment technologies and substance properties, which may cause risks to man and the environment. In the evaluation of sustainability related to the waste stage of a substance they have to be seen as less sustainable⁴²:

- › Metal containing compounds can be destroyed in waste incineration installations and distributed widely in the environment (if no abatement techniques are applied).
- › PBTs/vPvBs can be released to the environment in different disposal processes, e.g. evaporation or leaching in landfills.
- › Through thermal and biological processes in landfills, dangerous degradation products could be formed and reach the environment.
- › Problematic substances could contaminate material streams in recycling processes and be contained in products manufactured from recovered materials.
- › If substances are not recovered as such or as part of materials (e.g. plastics, metals), they are “lost” (inefficient use of resources).
- › Halogenated compounds can lead to the formation of dioxins and furans in thermal processes. These reactions can be enhanced by some metals, e.g. copper, which function as catalysts.
- › Substances with high water solubilities could reach surface waters in different processes of waste collection, separation and treatment.
- › Workers in waste treatment installations can be exposed to dangerous substances in products and chemical wastes (without knowing thereof), if articles are dismantled (opening of closed containers, e.g. batteries, dangerous operating fluids in cars) or shredded (dust formation). These situations don't normally occur during the use of a substance as such and in products.

› Nanoscale substances can disaggregate/de-agglomerate and be separated from the product. The behaviour and dangerous properties of nanomaterials in waste treatment installations, including physico-chemical risks are largely unknown. In particular for nanomaterials the precautionary principle should be applied: risks, which cannot be assessed, should be prevented in the first case.

› It can be assumed that wastes from industrial installations are properly disposed of. This is not the case for wastes from professional users or consumers. For example, electric and electronic equipment is still disposed of as household waste instead of being separately collected and treated. Therefore a lower content of hazardous substances is more important for products for professional and private uses.

The above examples show that additional adverse impacts may occur during the waste stage. Therefore, the waste stage is of high relevance in the assessment of sustainability. If one or more of the above listed items applies to the substance, this is to be evaluated as not sustainable.

2.2.5. Substitution potential

The substitution potential of a substance is a criterion applying rather to the alternatives of a use of a substance, than the substance itself. The substitution potential affects all of the substance-specific criteria.

The substitution potential describes the degree of availability of alternatives to the use of a problematic substance or mixture. If the use could be replaced by other substances / mixtures or by other measures, e.g. improved product design or change of processing techniques, and if this is economically and technically



feasible, the substitution potential enforces all negative evaluations of sustainability criteria, because of the potential to avoid the use of the substance or mixture.

If no alternatives are available, the further use of the substance or mixture (and if possible, the implementation of measures to reduce the non-sustainable aspects of the use of the substance) is inevitable and a negative evaluation of sustainability may be acceptable. However, the availability of alternatives should be checked regularly to take into account the technical progress and new information and substitution experience.

Because substitution is a complex process, no details can be provided in the frame of this guide and no concrete substitution scenarios presented. Practical support can be obtained from corresponding publications, for example the “technical rules for dangerous substances 600” (TRGS 600)⁴³ by the Federal Agency on Occupational Health and Safety. A good overview is given in the publication of Lißner and Lohse 2006. In Annex 7, some basic considerations on substitution are discussed which can be used for a first assessment. In this chapter only the guiding principles for consideration in substitution decisions are introduced:

- › Substitution should maintain or even improve the quality of a product.
- › Substitution should not lead to an increase or shift of risks for man and the environment.
Overall the risks should be reduced (for all subjects of protection).
- › Substitution can only be successful, if the technical precondition exists not only in the own company, but also at the customers'. This requires for example considering if technical processes are fine-tuned to a specific substance or mixture, which would require a change of the technological process if the substance or mixture were replaced.
- › Substitution is only a sustainable solution, if society and corporate costs for the use of alternatives remain under the costs of potential damage.

Relevance related to substance-specific criteria

The substitution potential has relevance to all substance-specific criteria. As said above, if a substance can not be substituted, the substance-specific criteria become less important. However in case of a substance which has to be considered as less sustainable according to these criteria, it has to be checked comprehensively whether alternative solutions exist.

Applicability of the criterion

In principle it can be assessed for any substance or mixture whether its use can be avoided or not. From this perspective, the criterion can be applied to any substance or mixture and any of their uses. The possibilities

to substitute decrease and are more complex, the more specific the functionality of a substance or mixture, or the more essential it is for the product or process it is used in.

Information basis

Different types of information are necessary to assess alternatives (substitution). These are among others:

- › Company internal sources for the assessment of financial feasibility of substitution,
- › Demands and statements of customers regarding the quality of products and processes
- › Public data bases on alternatives
- › Information on substance properties, uses and potential exposures and risks
- › Technical experience on substitution

Evaluation

Each enterprise has to decide for each case, whether or not the sustainability evaluation requires (or justifies) a substitution. The “simpler” and “cheaper” a substitution, the higher the substitution potential is and the more negative evaluations of sustainability are to be weighed. The evaluation cannot be standardized and no indicators can be given.

2.2.6. Benefit potential

The benefit potential of a substance or mixture influences, like the substitution potential, the evaluation of all substance-specific criteria. The benefit potential consists of the quality of the (end) products, the societal and environmental benefits from its use and the corporate benefits.

Substances can have very different functions in mixtures and in articles into which they are included. In order to determine the benefit potential, the relevance of the substance for the quality or functionality of the end product is to be identified. The functions of substances in end products can be allocated to different categories. One possible differentiation is introduced in the following and further explained in Annex 8.

Benefit potentials of substances are in most cases realised only in the end product they are used in. The benefits can be distinguished into:

- › Quality of (end) products. The substance contributes significantly to the product quality (e.g. long life spans, safety, weight).
- › Function of (end) products. The end product has got a high societal benefit which is realized to a high extent through the use of the substance.
- › Environmental benefits of products comprise of e.g. the improvement of product quality or the use of the product to improve the environmental quality (environmental technologies, e.g. photovoltaic).
- › Benefits for the company.

Relevance related to the substance-specific criteria

The evaluation of the benefit potential through a specific functionality of a substance, mixture or end product can influence the overall result of the evaluation of all substance-specific criteria. If benefits are very high, negative sustainability profiles may be acceptable or relativised.

The approach of balancing costs and benefits is pursued among other in socio-economic analyses (SEA)⁴⁴. A complete SEA is very complex and cumbersome but leads to valuable information to evaluate the sustainability of a substance. By using “common sense”, societal costs and benefits can be identified at a much rougher level, which although being much less differentiated and not “proven” frequently results in the same conclusions as a detailed SEA.

Applicability of the criterion

The criterion is applicable to all substances.

Information basis

The functionalities of substances are based on their properties and are normally known and intended by substance manufacturers and users.

The functionalities of mixtures are achieved by combining single substance and their properties are normally well known as well. However, sometimes the interaction of substances is important in mixtures, which may hinder the clear identification of contributions of the substance which is evaluated.

If substances are used in articles, only very superfluous functions as well as those which have a very high benefit can be unambiguously attributed to single substances. In most cases this is not possible, in particular for bulk chemicals with different uses. Here, the article as such should be submitted to a benefit assessment and issues of product design become more relevant.

Evaluation

The evaluation of the benefits of the use of chemicals can, depending on the type of actor, be viewed upon differently. This is particularly true for products which are very profitable for companies but are critical with regard to their impacts on the environment or society. The criterion should be used to analyse benefits of a product, but doesn't suffice to support an in-depth discussion of different stakeholders on the benefits of a substance.

2.2.7. Innovation potential

In all economic areas, the sustainability of products should be aimed at. The criteria for sustainable chemicals can influence the direction of innovation in a positive way, if already applied in the early stages of product de-

velopment. Herewith, the market position of the innovating company may also be improved.

The chances generated through the use of sustainable substances (avoiding problems of nonsustainable products, improving overall product qualities etc.) related to product and process innovations and the penetration of innovative products on the markets used should be considered as a “plus” in the evaluation of sustainability of products. The possibility to transparently document and communicate aspects of sustainability is very important in this context.

The sustainability of substances and products plays a role especially in ecologically-sensitive markets (ecologically produced products, like organic foods, clothing or furniture). In the future, demands for such products will be even higher for substances, which are contained in consumer products with high relevance for human health (e.g. clothing, cosmetics, products for infants, construction products for indoor use). The manufacture and use of sustainable substances is also important in filling respective company policies with life.

Relevance related to substance-specific criteria

The innovation potential has relevance to all substance-specific criteria. It enhances the importance of positive results of the application of these criteria.

Applicability of the criterion

The connection between the uses of sustainable substance with innovation activities is rather a question of the design of the innovation processes and its timing, than a question of the evaluation of sustainability of substances. The criterion can be applied to any substance or mixture.

Information basis

The criterion can be applied using internal knowledge of markets, products and production processes..

Evaluation

Different actors in society can achieve very different results in assessing the innovation potential of the use of a specific substance. This is the case especially for products which might offer a high economic potential, however they have to be considered as problematic regarding their impacts on man and the environment.

In this situation the criterion proposed at least supports a transparent analysis of the innovation potential of a substance or a mixture.

Sources:

- 6 www.gadsl.org
- 7 OSPAR: Convention on the protection of the marine environment of the North-East Atlantic
- 8 HELCOM: Commission on the protection of the marine environment of the Baltic Sea
- 9 Note that the authors of this guidance consider this type of product as such as being not sustainable as a low societal benefit is contrasted with high risks to humans and the environment and high losses of materials and energy.
- 10 This may take until 2018 for low volume substances which have been on the market before REACH entered into force.
- 11 <http://www.gsbl.de/index.html>
- 12 <http://ecb.jrc.ec.europa.eu/classification-labelling/search-classlab/>
- 13 Here, R-phrases can be directly translated to H-phrases of the CLP-regulation.
- 14 The H-phrases H224 – H226 apply to liquid substances. Details can be obtained from the translation tables of the CLP-regulation (Annex VII). The H-phrases can be used for very flammable and for flammable substances. A case-by-case decision should be taken on whether a substance falls into the category “red” or “yellow”.
- 15 The assignment of R-phrases is oriented towards the “Easy-to-use workplace control scheme for hazardous substances” of the Federal Institute for Occupational Safety and Health: http://www.baua.de/nn_37642/en/Topics-from-A-to-Z/Hazardous-Substances/workplace-control-scheme.pdf
- 16 Some substances penetrate the skin, enter the body and could cause adverse effects. The TRGS 900 lists substances for which occupational exposure limit values have been set in Germany. The column “comments” specifies if a substance penetrates the skin. http://www.baua.de/nn_16806/de/Themen-von-A-Z/Gefahrstoffe/TRGS/pdf/TRGS-900.pdf
- 17 The assignment of R-phrases is oriented towards the “Easy-to-use workplace control scheme for hazardous substances (einfaches Maßnahmenkonzept)” of the Federal Institute for Occupational Safety and Health: http://www.baua.de/nn_37642/en/Topics-from-A-to-Z/Hazardous-Substances/workplace-control-scheme.pdf
- 18 The H-phrase H370 addresses systemic damage according to the GHS. It corresponds to several R-phrases and is therefore mentioned in the columns “red” and “yellow”. Here, the “old” EU classification system is less ambiguous.
- 19 The H-phrase H314 is used for irritating substances of category 1A and 1B, which corresponds to the R-phrases R34 and R35.
- 20 Some substances penetrate the skin, enter into the body and may cause adverse effects. The TRGS 900 lists substances for which occupational exposure limit values have been set in Germany. The column “comments” specifies if a substance may penetrate the skin. http://www.baua.de/nn_16806/de/Themen-von-A-Z/Gefahrstoffe/TRGS/pdf/TRGS-900.pdf
- 21 The registration of low volume substances (production or import volume between 1 and 10 tonnes per year) will be finalized by 2018. However, for these substances, the required data set to be generated will not allow a thorough PBT/vPvB assessment, as no BCF or half-life needs to be determined, but only the LogKow and easy degradability.
- 22 <http://oberon.sourceoecd.org/vl=7718146/cl=11/nw=1/rpsv/cw/vhosts/oecdjournals/1607310x/v1n3/contp1-1.htm>
- 23 The CLP-regulation has only one category for acute aquatic toxicity. The H-phrases analogous to the R51 and R52 only exist in combination and address the chronic toxicity.
- 24 The criteria are given in the Annex.
- 25 It is possible that a substance is inherently not degradable and has a LogKow of more than 4. These are indications that the substance may be a PBT/vPvB. Further data is necessary for a comparison of the respective criteria (e.g. simulation test on degradability and/or study determining a BCF).
- 26 Also gases other than CO₂ are relevant for the climate, e.g. methane and SF₆. All emissions of substances are normalized to the effects of CO₂ and the greenhouse potential is then measured in CO₂-equivalents.
- 27 ICCA International Council of Chemical Association 2009: Innovations for Greenhouse Gas Reductions. A lifecycle quantification of carbon abatement solutions enabled by the chemical industry, July 2009; http://www.icca-chem.org/ICCADocs/ICCA_A4_LR.pdf
- 28 The resource efficiency of the manufacture of a substance is to be correlated with the benefits of its use regarding the resource use along the supply chain, in order to obtain a full picture. However, this requires in-depth knowledge on the uses and application processes of a substance and is a very complex task, which cannot be elaborated in this guide.
- 29 In a holistic perspective, additional production factors would be included, such as the use of machines and auxiliary materials or land consumption. In order to make the criterion manageable at company level, only the above mentioned factors are used.
- 30 http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennnummer&Suchwort=3734
- 31 The Rio Declaration has been stated during the conference of the United Nations for Environment and Development, taking place in Rio de Janeiro from June, 3.-14. 1992 (see <http://www.quetzal-leipzig.de/printausgaben/ausgabe-02-umwelt-und-entwicklung-in-lateinamerika/erklarung-der-unced-19093.html>).
- 32 Further explanation to this criterion is provided in Annex 4.
- 33 The “REACH guidance on exposure assessment and communication in the supply chain” including examples can be downloaded at: <http://www.cefic.org/Files/Publications/Doc-1-Part-1-to-3-Practical-Guidance-final.pdf> (english version) and <http://www.vci.de/default~cmd~shd~docnr~125022~lastDokNr~102474.htm> (german version).
- 34 The guidance is available at the European Chemicals Agency: http://guidance.echa.europa.eu/guidance_en.htm
- 35 Guidance for a detailed assessment of emissions and exposures of dangerous substances at workplaces can be found in the “Easy-to-use workplace control scheme for hazardous substances” (Einfaches Maßnahmenkonzept) of the Federal Agency on Occupational Health and Safety, including help for practical risk management measures.
- 36 Source: Federal Environment Agency: Guidance for the use of environmentally sound substances – part 2, Berlin 2003; <http://www.umweltbundesamt.de/wasser-e/themen/stoffhaushalt/umweltvertraegliche-stoffe/inventare.htm>. The table has been slightly modified.
- 37 As preliminary guiding value an annual loss of materials of less than 0.001 to 1% compared to the input amount to the system can be used. The target values have to be defined specifically for sectors, substances and processes.
- 38 Chapter 5.3.1 of the REACH-guide; <http://www.cefic.org/Files/Publications/Doc-1-Part-1-to-3-Practical-Guidance-final.pdf> (english version) and <http://www.vci.de/default~cmd~shd~docnr~125022~lastDokNr~102474.htm> (german version)
- 39 Here, the criteria “mobility” and “emission potential” are not considered. However, it is recommended to view the use amount in conjunction with these criteria, because for example even sensitive or vulnerable groups users may not be at risk, if the substance has a low mobility and is used in closed systems.
- 40 The concentration in a mixture is only specified in the safety data sheet if the substance is classified as dangerous. It may be useful to contact the supplier for more information.
- 41 Due to this, substances have to be stable and easily separable.
- 42 The ECHA guidance document on information requirements and chemical safety assessment (IR/CSA – R18) contains a part on assessing risks of substances in their waste stage, including guidance on quantitative assessments. This part of the guidance is currently under revision.
- 43 www.baua.bund.de/nn_78960/de/Themen-von-A-Z/Gefahrstoffe/TRGS/pdf/TRGS-600.pdf
- 44 The socio-economic analysis aims at a structured compilation of societal benefits and costs of a certain issue. In the past, such analyses have among others been performed in the frame of the “existing substances programme” of the EU in order to identify those measures, which lead to the highest risk reduction in the use of a substance and which are connected with the lowest costs and highest societal benefits. In a SEA, different parameters are quantified and described as costs and savings. Under REACH, the socio-economic analysis will be applied by industry in the context of applying for an authorization of a use of a substance. A separate guidance document is intended to be developed.

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3.0

Golden rules



GOLDEN RULES

The following “10 golden rules” summarise the most important principles of sustainable chemicals. Of course, this is only possible by making some rather rough simplifications. Therefore, the following rules do not replace the detailed explanation of the previous chapters, but highlight the core issues to consider and facilitate orientating chemicals management towards sustainability.



1. If possible, only use substances (as such, in mixtures or in articles) which are not mentioned on lists of problematic substances!



3. As much as possible use substances which are not dangerous to human health (in particular none, which are classified as carcinogen, mutagen or reprotoxic), which are easily degraded, don't bioaccumulate and don't widely disperse in the environment!



2. Assess the different uses and potential users of the substance as such, in mixtures or in articles in detail and take responsibility for the consequences of its use. Never look at the substance in isolation but think through the entire lifecycle in the evaluation!



4. Prefer substances which are available in excess or made from renewable resources to substances which are scarce and produced from fossil raw materials!



5.
Avoid long-distance transports at any stage of the supply chain, in particular for substances which you use in high amounts!



6.
Pay attention to a low energy and water consumption of substances you use in large amounts as well as to a low generation of wastes in manufacturing and use!



7.
Don't use substances, which require a high degree of risk management according to the Easy-to-use workplace control scheme for hazardous substances or the COSHH approach!

8.
Assess whether your suppliers conform to high environmental and social standards. Select substances considering the transparency of the supply chain and the commitment of its actors to sustainability!

9.
Your suppliers should elaborate environmental product declarations for substances supplied in large amounts. In these EPDs they should document the resource and energy consumption related to the manufacture of the substance, as well as generated greenhouse gas emissions. Make EPDs yourself, if possible, to document the sustainability of your products.



10.
Conduct independent studies on the environmental and health risks of the substances and / or products you want to place on the market. Provide specific and high quality data, such as test results.

Furthermore products should not be put on the market for which a societal benefit and a benefit for consumers can not be identified.

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4.0

Outlook

OUTLOOK

This guide should support manufacturers, formulators and end users of substances and mixtures to consider aspects of sustainability in selecting their chemicals.

TABLE 16: COMPARISON OF SUSTAINABILITY PROFILES OF FORMALDEHYDE AND PHENOL

SUBSTANCE-SPECIFIC CRITERIA	FORMALDEHYDE	PHENOL
Mentioning on substance lists	Green	Green
Physico-chemical properties	Green	Green
Human toxicity	Red	Red
Dangerousness for the environment	Green	Green
Mobility	Red	Red
Origin of substance: Environmental and social standards	White	White
Greenhouse potential including upstream chains	Green	Yellow
Resource consumption including upstream chains	Red	Red

The criteria introduced in Chapter 2 enable analysing which aspects of a substance require action or further information gathering. Table 16 shows the results of assessing two example substances with the help of the substance-specific criteria.

Both substances are critical regarding their human toxicity, their mobility and their resource consumption. Most criteria are evaluated with a similar outcome. Only the greenhouse potential appears to be higher for phenol. For both substances, no information is available on the implementation of environmental and social standards in the supply chain.

For both substances, the sustainability profile shows that measures could improve the sustainability of these substances. Due to the dangerous properties for humans and the high mobility of the substances, the possibilities of substituting with alternatives with less critical properties should be assessed. If no alternatives are available, the problematic impacts may be reduced by the implementation of risk management measures. In order to clarify environmental and social standards in the supply chain, targeted requests are necessary in both cases.

05. LITERATURE

BAuA: Easy-to-use workplace control scheme for hazardous substances. http://www.baua.de/nn_37642/en/Topics-from-A-to-Z/Hazardous-Substances/workplace-control-scheme.pdf?

Federal Environment Agency: Guidance for the use of environmentally sound substances, part 2, Berlin 2003. <http://www.umweltbundesamt.de/wasser-e/themen/stoffhaushalt/umweltvertraegliche-stoffe/inventare.htm>

ICCA International Council of Chemical Association 2009: Innovations for Greenhouse Gas Reductions. A life cycle quantification of carbon abatement solutions enabled by the chemical industry. July 2009; http://www.icca-chem.org/ICCADocs/ICCA_A4_LR.pdf ACC A

Lißner, L.; Lohse, J. (2006); Braucht Substitution mehr Staat oder mehr Markt? In: UWSF – Z Umweltchem Ökotox 18 (3) 193 – 200

REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

REGULATION (EC) No 1272/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

ABBREVIATIONS

ARTICLE	AN OBJECT WITH A SPECIAL SHAPE, SURFACE OR DESIGN WHICH DETERMINES ITS FUNCTION TO A GREATER DEGREE THAN DOES ITS CHEMICAL COMPOSITION
BAT	BEST AVAILABLE TECHNIQUES
BCF	BIOCONCENTRATION FACTOR
BREF	BEST AVAILABLE TECHNIQUES REFERENCE DOCUMENT
CAS	CHEMICAL ABSTRACT SERVICE
C&L	CLASSIFICATION AND LABELLING
COSHH	CONTROL OF SUBSTANCES HAZARDOUS TO HEALTH. APPROACH FROM GREAT BRITAIN FOR THE DERIVATION OF RISK MANAGEMENT MEASURES FOR WORK PLACE
CLP	CLASSIFICATION, LABELLING AND PACKAGING
CMR	CARCINOGENIC, MUTAGENIC OR REPROTOXIC SUBSTANCE
DNEL	DERIVED NO EFFECT LEVEL
DPD+	METHOD TO IDENTIFY LEAD SUBSTANCES IN MIXTURES BASED ON THE DANGEROUS PREPARATION DIRECTIVE
ECHA	EUROPEAN CHEMICALS AGENCY
EDC	ENDOCRINE DISRUPTING CHEMICAL
EMKG	EINFACHES MASSNAHMENKONZEPT GEFÄHRSTOFFE (SIMPLE CONCEPT OF MEASURES FOR DANGEROUS SUBSTANCES) = EASY-TO-USE WORKPLACE CONTROL SCHEME FOR HAZARDOUS SUBSTANCES
EPD	ENVIRONMENTAL PRODUCT DECLARATION
EXPOSURE	EXPONERE (LAT): TO BE SET OUT; CONTACT BETWEEN A CHEMICAL SUBSTANCE OR A PHYSICAL OR BIOLOGICAL AGENT ON THE ONE HAND AND AN ORGANISM OR AN ENVIRONMENTAL COMPARTMENT ON THE OTHER.
HACCP	HAZARD ANALYSIS AND CRITICAL CONTROL POINT
LCA	LIFECYCLE ANALYSIS
LC50	LETHAL CONCENTRATION; CONCENTRATION CAUSING 50% OF TEST ORGANISMS TO DIE
LOGKOW	LOGARITHM OF THE PARTITIONING COEFFICIENT BETWEEN WATER AND OCTANOL
MIXTURE	A MIXTURE OR SOLUTION COMPOSED OF TWO OR MORE SUBSTANCES (CLP REGULATION). THIS TERM REPLACES THE TERM "PREPARATION".
PBT	PERSISTENT, BIOACCUMULATIVE AND TOXIC SUBSTANCE
PC	PHYSICO-CHEMICAL
PEC	PREDICTED ENVIRONMENTAL CONCENTRATION
PNEC	PREDICTED NO EFFECT CONCENTRATION
REACH	REGISTRATION, EVALUATION AND AUTHORISATION OF CHEMICALS (NEW EUROPEAN CHEMICALS REGULATION)
SME	SMALL AND MEDIUM SIZED ENTERPRISES
SVHC	SUBSTANCE OF VERY HIGH CONCERN
VPVB	VERY PERSISTENT AND VERY BIOACCUMULATIVE SUBSTANCE

ANNEXES

ANNEX 1: LINKS TO SUBSTANCE LISTS

Candidate list for authorization of substances of very high concern

http://echa.europa.eu/chem_data/candidate_list_table_en.asp

Priority and priority hazardous substances of the Water Framework Directive

http://ec.europa.eu/environment/water/water-framework/priority_substances.htm

Helcom list of substances of possible concern:

http://www.helcom.fi/Recommendations/en_GB/rec19_5/

Ospar list of substances of possible concern (Datenbank zum Suchen von Stoffen) und Liste zum herunterladen:

http://www.ospar.org/content/content.asp?menu=00950304450000_000000_000000

Ospar list of substances for priority action:

http://www.ospar.org/content/content.asp?menu=00940304440000_000000_000000

Stockholm Konvention POPs:

http://www.pops.int/documents/convtext/convtext_en.pdf,
<http://chm.pops.int/>

Montreal Protokoll:

<http://ozone.unep.org/>

Kyoto Protocol

http://europa.eu/legislation_summaries/environment/tackling_climate_change/l28060_en.htm

Endocrine disrupting chemicals

http://ec.europa.eu/environment/endocrine/documents/sec_2007_1635_en.htm

ANNEX 2: PBT/VPVB-CRITERIA OF REACH ANNEX XIII

CRITERION	PBT	VPVB
Persistence		
Half-life in marine water or	> 40 days	> 60 days
Half-life in freshwater or estuaries or	> 40 days	> 60 days
Half-life in marine sediments or	> 180 days	> 180 days
Half-life in freshwater sediments	> 120 days	> 180 days
or estuarine sediments or		
Half-life in soil	> 120 days	> 180 days
Bioaccumulation potential		
Bioconcentration factor	> 2 000	> 5 000
TOXICITY		
Concentration, below which no effects are observed in marine or freshwater organisms (no-observed effect concentration – NOEC)	< 0,01 mg/l	Nicht anwendbar
Substance is		
Or	Carcinogen (Cat 1 or 2), mutagen (Cat 1 or 2) or reprotoxicants (Cat 1, 2 or 3)	
Classification according to Dir 67/548/EEC	T, R48 or Xn, R48	

ANNEX 3: LINKS TO DATA BASES AND EVALUATION INSTRUMENTS

3.1 PROBAS Database of the Federal Environmental Agency

In the Probas database, information on different materials and processes are compiled. For a defined reference amount of a product (e.g. 1 kg of copper), the required inputs are provided (energy, materials, water). The energy consumption is expressed as aggregated values (KEA/KEV), which describe the cumulated energy consumption along the supply chain (table “resources”). The water consumption can be extracted from the table “inputs”. In the table “wastes” the amounts of waste produced along the supply chain are listed.

<http://www.probas.umweltbundesamt.de/php/index.php>

3.2 MIPS-concept of the Wuppertal institute for climate, environment and energy GmbH and further LCA tools

MIPS stands for “material input per service unit”. According to this concept, the environmental impacts of a substance, material, product or service are calculated

using the material consumptions necessary for their manufacturing or supply. On the MIPS web pages an excel file is provided for structuring respective data collection. Furthermore, lists with material intensities of different raw materials and chemicals are given.

Related to the current guide, the values for material and water consumption can be used. Energy consumptions and the renewability of raw materials are not considered by MIPS. However, selfstanding evaluations can be done.

http://www.wupperinst.org/de/projekte/themen_online/mips/index.html

The Directorate Research of the European Commission provides tools and data bases for lifecycle analyses on their website free of charge.

<http://lca.jrc.ec.europa.eu/lcainfohub/directory.vm>

ANNEX 4: FURTHER PUBLIC AVAILABLE SOURCES OF INFORMATION

This annex describes some sources for additional information. It is not complete, however it offers valuable help to work with the sustainability criteria. In many cases sector-specific information is available. For this the respective associations should be contacted.

Review on sustainable chemistry

Das Hintergrundpapier des Umweltbundesamtes zur Nachhaltigen Chemie gibt einen guten Überblick über die Vielfalt der Themen, die zur nachhaltigen Chemie gehören. Es kann heruntergeladen werden von der folgenden Internet-Seite: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=3734.

Approaches to set sector-specific priorities in risk management

The HACCP concept (“Hazard Analysis and Critical Control Point”) has been developed especially for the food industry. However its principles can be applied in other sectors of industry, also. More details can be found at http://www.bfr.bund.de/cm/234/fragen_und_antworten_zum_hazard_analysis_and_critical_control_point_haccp_konzept.pdf.

Sector-specific documentation of best available techniques

Saving of resources and costs can be achieved by

implementation of best available techniques. They are documented for many sectors in the so-called BREF documents, see <http://eippcb.jrc.es/reference/>

Sector-specific lists of problematic substances

The “Global Automotive Declarable Substance List” of the automotive industry is a corporate instrument for the management of problematic substances. It is publicly available (www.gadsl.org). Lists of problematic substances which can be relevant for all branches are documented in Annex I of this guidance.

Data bases on hazardous substances

Examples for public available data bases on hazardous substances are “Der gemeinsame Stoffdatenpool von Bund und Ländern” (<http://www.gsbl.de/index.html>) and the European data base on classification and labelling, Joint Research Center, Ispra, Italy (<http://ecb.jrc.ec.europa.eu/classification-labelling/search-classlab/>).

Identification of risk management measures for work places

The “Easy-to-use workplace control scheme for hazardous substances” (Einfaches Maßnahmenkonzept Gefahrstoffe, EMKG) of the Federal Agency for Occupational Health and Safety supports enterprises’ decisions on risk management measures to ensure safe use of substances and mixtures. It is based on a limited amount

of information which are available in companies (e.g. in safety data sheets (for details see http://www.baua.de/de/Themen-von-A-Z/Gefahrstoffe/EMKG/EMKG__content.html)).

Guidance on chemical safety assessment, exposure assessment and risk characterisation:

The explanation and support of a comprehensive assessment of emissions along the lifecycle of a substance is not possible in this guide. However, publications on this topic can be found on the web in much detail.

The European Chemicals Agency publishes an comprehensive Guidance on Information Requirements and the Chemical Safety Assessment. It describes – besides others – the methods for assessing exposures and characterizing risks from the use of chemicals⁴⁶. ECHA publishes further guidance on all topics related to REACH (see http://guidance.echa.europa.eu/guidance_en.htm).

For the structured communication on uses the so called “Use Descriptor System” has been developed in the framework of REACH. It is described in Part R12 of the ECHA Guidance on information requirements mentioned above.

The VCI REACH guidance for practitioners introduces to the topics exposure assessment and communication in

the supply chain with several recommendations on the implementation in practice. The guidance and the case studies can be downloaded from the following website: <http://www.vci.de/default~cmd~shd~docnr~125022~1astDokNr~102474.htm> (german version) / <http://www.cefic.org/Files/Publications/Doc-1-Part-1-to-3-Practical-Guidance-final.pdf> (english version).

Exposure estimation tools

Several instruments have been developed to support the tasks of exposure estimation and risk characterisation. An overview is given in Part IV of the above mentioned REACH Practical Guide. Last year the second version of the exposure estimation tool ECETOC TRA (“Targeted Risk Assessment”) has been published. It is available for free (<http://www.ecetoc.org/tra>).

Guidance for Substitution

Guidance for substitution is given in a publication of the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAUA) (Technische Regel Gefahrstoffe (TRGS) 600, www.baua.bund.de/nn_78960/de/Themen-von-A-Z/Gefahrstoffe/TRGS/pdf/TRGS-600.pdf). A good overview on the topic is given in the publication of Lißner and Lohse (Lißner, L.; Lohse, J. (2006); Braucht Substitution mehr Staat oder mehr Markt? In: UWSF – Z Umweltchem Ökotox 18 (3) 193 – 200).

ANNEX 5: CLASSIFICATION OF SUBSTANCES AND SAFETY INFORMATION IN THE SUPPLY CHAIN

Three of the eight substance-specific criteria described in chapter 2 of this guidance are based on the existing classification of a substance (physico-chemical properties, human toxicity and ecotoxicity (c.f. chapters 2.1.2, 2.1.3 and 2.1.4)). This information is to be generated by manufacturers and importers and is normally available at the end users of chemicals in form of safety data sheets, REACH information or product labels. Information on the dangerousness for the environment (c.f. Chapter 2.1.4) and on the mobility (c.f. Chapter 2.1.5) is normally contained in the safety data sheet as well. Therefore, some basic information and legal background is given on this information source.

By the end of 2010, substances may be either classified or labelled according to the EU Dangerous Substances Directive (67/548/EEC or the German TRGS 200 respectively) or according to the European Classification and Labelling Regulation (CLP-regulation, EC/1272/2008).

The placer on the market may choose which of the systems he applies or even if he uses both simultaneously. By 2015, all substances are to be classified and labelled only according to the CLP-regulation

Under REACH, manufacturers of substances are required to compile and/or generate information in the scope of its registration. The extent of information depends on the registered annual volume. Parts of this information are to be forwarded to the downstream users of substances and mixtures via the safety data sheet. The information is to be provided in accordance with REACH article 32 and the results of tests and studies are to be provided directly, if possible. Information which is not (yet) available or not legally required for the registered tonnage as specified in the Annexes VI – XI of REACH should be indicated in the safety data sheet (remark “not tested” or “information not available”).

Downstream users of substances and mixtures receive respective safety information from their suppliers. In the transition period of REACH, they should pay particular attention to new information on a substance as such or contained in mixtures, especially after its registration.

The lack of information about the properties of substances and mixtures in the safety data sheet and / or those marked with “not applicable” are not transparent, as it is not clear if tests have been performed to show that a dangerous property is not present or if no tests sufficient for a classification have been performed. If information is ambiguous, the supplier of substances or

mixtures should be consulted to clarify the information basis⁴⁷. This is particularly relevant when alternatives are compared in the context of assessing substitution possibilities.

If a substance or mixture is not classified as dangerous⁴⁸, in principle no safety data sheet must be provided⁴⁹. However, other properties of a substance or mixture (e.g. dustiness) may require the communication of risk management measures to ensure safe handling. According to REACH article 32, suppliers/manufacturers have to communicate such information. The format for forwarding this information is not legally defined.

ANNEX 6: FURTHER INFORMATION ON THE EMISSION POTENTIAL

Relevance of the emission potential

The emission potential expresses, what amount of a substance is lost or released during its lifecycle and what exposures and pressures for man and the environment may result. Emissions are normally assessed for single substances, rather than for several substances at the same time. If mixtures are assessed, the emission potentials are to be evaluated separately for its components, reasonably for those with the highest mobility and / or the most severe dangerous properties for humans or the environment.

Emissions from products and processes can be reduced by implementing risk management measures, which should be considered in the assessment of the emission potential, if the respective information is available in the company⁵⁰.

Lifecycle of a substance

In order to review the emission potential of a substance (as such or as a component of a mixture or article), all of its uses need to be considered. Normally, each use is a sequence or combination of the following lifecycle stages:

- › Manufacture (or import)
- › Formulation / mixing of mixtures (frequently several mixing steps in one or several companies)
- › Use of a mixture in processes (as processing air or for the manufacture of articles, in which the substance is integrated into)
- › Use of the article (service life)
- › Disposal of the articles and production wastes, which are produced along the lifecycle.

Depending on the type of substance and its uses, each of the lifecycle steps may occur once, more than once or not at all. Some substances are used in different applications and hence, several lifecycles should be assessed.

According to the European chemicals regulation REACH, for all substances registered in amounts exceeding 10 t/a and which are classified as dangerous, an emission estimation and exposure assessment is to be performed. The instruments supporting this assessment are for example a system to describe uses in a standardised way (use descriptors⁵¹) and simple models⁵² for estimating emitted amounts of a substance from processes and products.

The aim of the so called chemical safety assessment under REACH is the identification of risk management measures, which are necessary to ensure safe handling and use of a substance along its entire lifecycle, including the use in articles and the waste disposal stage.

When deciding on substitution, the replacement of critical substances with less critical alternatives, as well as other measures such as a different product designs or organisational and technical measures in the production process are relevant. In any case, various factors influence which option is most efficient or feasible in a specific context. In the following, some of these factors are briefly introduced. For detailed information, specific literature on substitution should be consulted.

Maintaining or improving product quality

The use of alternatives should improve the quality of a product towards more sustainability; in no case should it worsen the product quality. The qualities to maintain or improve are e.g. the lifespan of the product, safety functions during use, the practicality of a product or a product's weight (material input).

If the product design is changed and thereby the use of a critical substance is phased out (e.g. constructive flame retardation instead of the use of chemical flame retardants) sustainability can be realised through the adoption of that change in other products. This could happen either as a "technological spill over", where a systematic change is used across different technologies or simply through the integration of the changed product into complex articles as a component.

The quality of products is sometimes defined by the customers, who may demand certain characteristics or qualities. In these cases, the question of the availability of alternatives is limited by these demands - sometimes with very low tolerances. On the other hand, if customers define their quality criteria with respect to the content or the absence of certain substances, the search for alternatives is obviously welcome and not limited by any conditions.

No shift of risk, no increase of total risk

If non-sustainable substances are replaced by other substances, any risks for human health or the environment should be carefully observed that they are not increased. This can be ensured if the substitute has less dangerous properties for human health and the environment (c.f. Chapter 2.1.3 and 2.1.4), if it is less mobile (c.f. Chapter 2.1.5) and / or is used in significantly lower amounts (c.f. Chapter 2.2.3).

For non-chemical alternatives, but also if alternatives are used, further risks have to be considered:

- › If a substance is replaced by technical measures, risks for workers may shift from chemical stress to physical or other stress⁵³
- › Substitution may result in the loss of safety of the product, which could be an indication for a worse quality (e.g. higher flammability due to the abandonment of flame retardants).
- › A changed (substance) design could deteriorate the manageability of products.

Technical preconditions in the own company and at the customers'

The alternatives for non-sustainable substances have to be applicable in existing technology, not only inside own production processes, but also at the customers'. In particular in sectors where complex and very fast production processes occur (e.g. newspaper printing) or very complex articles are manufactured (e.g. electronic devices), production processes and machines are fine-tuned to the use of particular chemicals. In substitution processes, the entire supply chain and all related conditions and technical requirements are to be assessed.

Economic issues

The substitution of substances is connected to different types of economic risks: the technical feasibility, the frequently missing information on the dangerous properties of substitutes (and resulting difficulties in comparing alternatives), the financing of research activities, the practical and technical implementation of substitution, as well as the risk of lower acceptance of new products on the market. Substitution may at the same time offer many opportunities to increase product quality, enforce approaches for sustainable innovation and thereby improve the market position or enter new markets.

Each enterprise has to assess substitution issues for itself, balance risks and opportunities connected with a substitution and make a respective decision.

The benefit potentials can be allocated to different areas, which are briefly described in the following.

Quality of (end) products

The functionalities of substances⁵⁴, which improve product qualities in the sense of sustainability, are for example functionalities that:

- › Prolong the lifespan (e.g. reduced deterioration due to weathering by the use of UV-stabilisers or corrosion inhibitors);
- › Reduce the material consumption for the manufacturing of a product (e.g. lower material density through the use of nanomaterials);
- › Enhance safety or enlarge the benefits of other products (e.g. lubricants increase safety and reduce abrasion of machinery).

Societal benefits

To evaluate the societal benefits of a substance, the function of the end product is to be assessed as well as the potentially caused impacts on human health. For example, the societal benefit of fragrances in erasers, CDs or similar articles can be questioned. However, a significant benefit can be seen in the use of silver in textiles which makes clothes better tolerable for persons with neurodermatitis. The use of biocides in metal working fluids improves workers' health by preventing or at least significantly reducing the growth of pathogenic bacteria.

For the reflection of societal benefits, the following questions should be answered:

- › What qualities does a substance add or contribute to an end product?
- › What benefit does society have from the existence of that property? Are there indications that the function is wanted or objected to?
- › Does the property enhance the health conditions of consumers and workers?

Environmental benefits

Environmental benefits are realised by improving product quality (prolonged lifespan, resource savings) and frequently overlap with the previously mentioned items. Further environmental benefits of substances can be seen in that they (contribute to) improve the quality of the environment. Some examples are environmental remediation technologies: chemical wastewater cleaning, use of chemicals for the remediation of environmental damage. Further benefits regarding sustainability are always connected to a chemical, when it is important for the function of a product that replaces technologies carrying heavy environmental burdens (e.g. silica in solar cells instead of energy production based on fossil fuels like coal).

Economic benefits

A sustainable decision on the manufacture and use of chemicals must also consider the economic consequences for enterprises. Normally, it is not possible to immediately phase out the production or use of a chemical, which has been evaluated as not sustainable. The economic survival of companies is to be ensured and may relativise the non-sustainability of chemical. However, sustainability of products should gain a higher importance in the long-term goals of companies.

SOURCES:

- 45 The PBT/vPvB criteria of Annex XIII are currently under revision
- 46 The guidance is available at the European Chemicals Agency: http://guidance.echa.europa.eu/guidance_en.htm
- 47 If a substance is not classified because no data are available, at a later stage it can turn out to be of higher concern than the substance to be substituted. It would neither be sustainable nor economically reasonable to take a decision based on an incomplete data basis. In this case it is to be decided if new data are awaited or if a substitute is excluded due to lack of data, if own data are generated or substitution is implemented despite the lack of information.
- 48 According to REACH, a safety data sheet has to be provided also for PBTs/vPvBs and substances on the candidate list for authorisation, even if they are not classified.
- 49 Unless the substance is of very high concern and listed on the candidate list for authorisation.
- 50 In order to remain manageable, this guide is limited to a first and rough estimation. Furthermore, emissions with view to sustainability, even if they do not lead to exposures because of appropriate risk management measures, should be prevented, in order not to lose substances (resource

consumption).

- 51 C.f. the guidance document by the European Chemicals Agency on information requirements and the chemical safety assessment, part D. This guidance is available on the website of the European Chemicals Agency (http://guidance.echa.europa.eu/guidance_en.htm).
- 52 E.g. ECETOC TRA Version 2. An easy to understand description of instruments on exposure assessment can be found in the indepth chapter on exposure assessment of the REACH guide for practitioners (available on the web at <http://www.vci.de/default~cmd~shd~docnr~125022~lastDokNr~102474.htm>).
- 53 For example can solvent-based paints be replaced if a drying installation is used. The dryer may expose workers to higher temperatures and potentially higher levels of noise by the exhaust gas system of the drying installation.
- 54 If the sustainability of materials or end products is evaluated, further and other criteria are relevant as compared to assessing chemicals only, e.g. the possibility to repair or dismantle products for recycling. The following explanation is limited to functionalities of sustainability, which can be evaluated and influenced by manufacturers and users of chemicals.

EDITORIAL INFORMATION

GUIDE ON SUSTAINABLE CHEMICALS

A decision tool for substance manufacturers,
formulators and end users of chemicals

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