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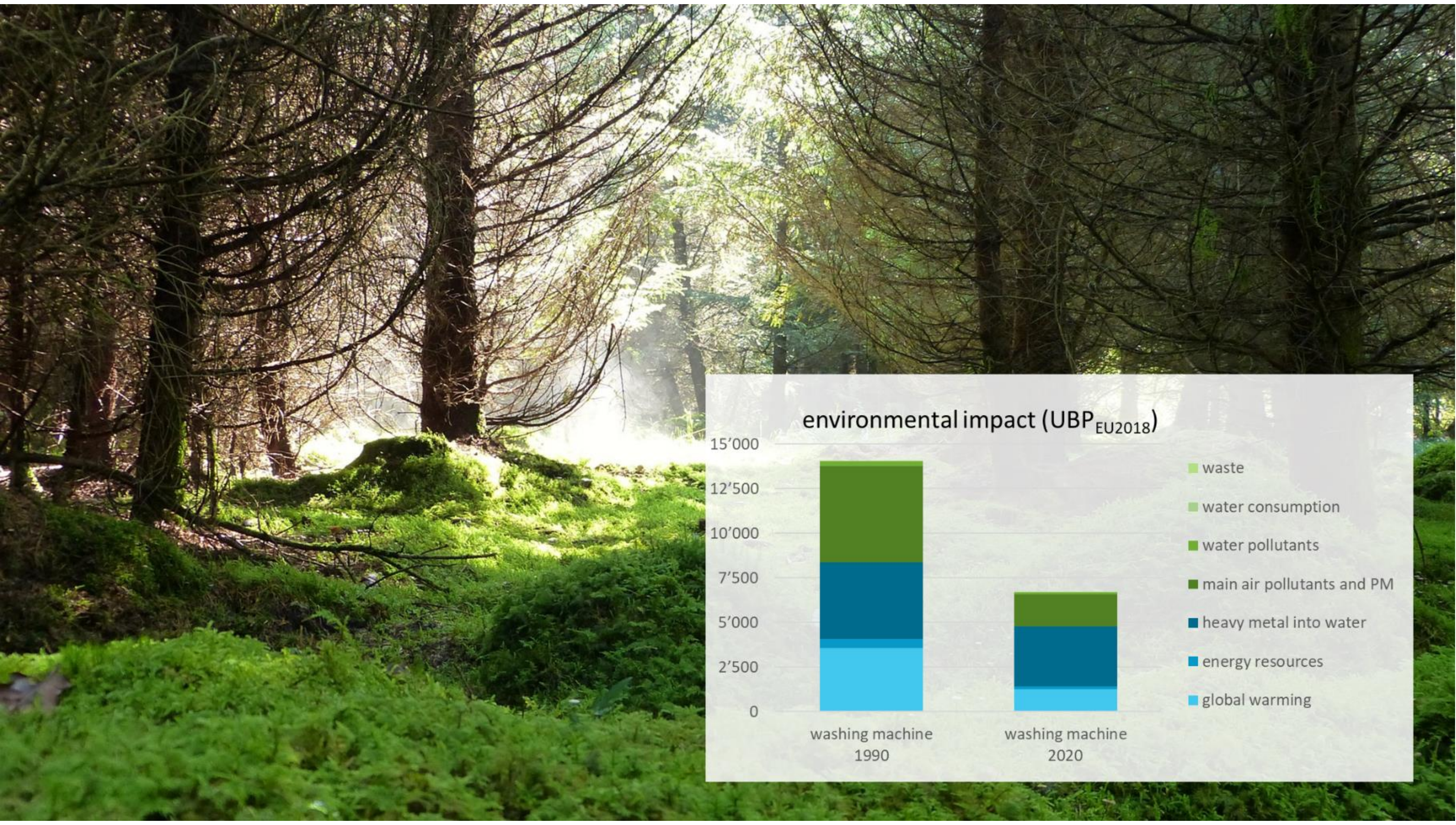

Environmental assessments for products, processes and business sites

Ecological Scarcity Method according to the eco-scout standard

April 30, 2021

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1. WHY ENVIRONMENTAL ASSESSMENTS?

With increasing frequency, corporations and also other organizations are facing the situation of having to differentiate between various implementation variants in the ecological sense. The question: "What is more ecological and by how much?" can cover products, processes, but also business sites. In the case of the latter, the question involves the chronological ecological development of a site, for example from one year to the next, i.e. as a timeline.

Understandably, fixed conditions are linked to such company decisions: The results of an assessment to support a decision must be complete, transparent, easy to follow, reproducible, and objective. The latter means that the assessment result must be independent of its author.

The eco-scout standard has been developed to meet these requirements. Corporations in particular have a great interest in placing their ecologically relevant decisions on a secure footing and also being able to justify the decision-making to third parties in a manner that is easy to follow. This requirement therefore results not only for internal use of the assessments as the basis for decisions, rather also in exchanges with third parties such as customers, authorities, banks, competitors, shareholders, associations etc.

1.1. PROPERTIES OF EXISTING ASSESSMENT METHODS

The methods described to date in the literature take account of either only individual environmental impacts, for example the 'carbon footprint' approach, which only considers the effective climate aspect of the environmental impacts. By definition, other major impacts, which can possibly have significantly more far-reaching effects, are left out of the analysis. There are also a whole range of assessment methods in which, in a type of utility value analysis, the author of the assessment himself specifies which impacts are to be analyzed in which way. These assessments are subjective, as they depend on the appraiser and their appraisal. This is why they have practically no informative value for third parties.

1.2. WHAT ARE THE DISADVANTAGES OF EXISTING METHODS?

From the point of view of the corporations who want to include environmentally relevant aspects in their decisions, in the case of existing methods this results in a lack of completeness, or also in subjectivity. Both, for example, are great hindrances to industrial projects with a certain pressure for justification in relation to the public. These disadvantages then lead to a lack of transparency. This is particularly disturbing when large sums are to be invested for environmentally compatible development and, ultimately, reliable verification of this cannot be provided in a convincing and comprehensible manner.

2. NEED FOR A STANDARD

2.1. USE FOR INTERNAL PURPOSES

The initial motivation for a corporation to create environmental assessments is to obtain information regarding ecological facts. This can be purely informal or also within the framework of a structured self-commitment, for example an environment management system according to EMAS or ISO 14001. If these results are also to be considered in the planning, greater emphasis must be placed on reproducibility. This means that in the case of investments in environmental measures for a location, for example, the required bases for decisions for different areas of the company such as controlling, quality assurance, company management etc. must be transparent and comprehensible. This requires an evaluation method where the result does not depend on the person performing the work, but rather on an algorithm that leads to the same results from the same facts for all users.

2.2. USE TOWARDS THE OUTSIDE WORLD

Especially with regard to environmental protection, many corporations have caught the attention of the public and want to or must also account for ecological aspects of the company activities. More specifically, this can involve reports on improvements to the environmental impact from production sites or even explanations regarding product decisions where environmental considerations have played an important role. In all these cases, the company must first ensure that the impression of arbitrariness in the creation of these assessments is avoided. This impression – experience has shown – arises relatively easily with the external observer, as it is regularly the case that such decisions are mainly based on economic mechanisms. The suspicion that positive environmental behavior could be self-attested only for economic reasons must therefore be confronted. That can only occur effectively if the environmental assessment method is free of subjective criteria of the author. Furthermore, it must be based on assessment criteria that cannot be influenced by the company using them and, over and above this, is the same for all other users.

Especially in communication with customers, it is of great importance to be able to refer to neutral assessment results. In many cases, these are also used by the customers and - for this reason alone - should be comprehensible and free of discernible vested interests.

3. REQUIREMENT TO AVOID ARBITRARINESS: SEPARATION OF POWERS

Arbitrariness - and even if it is only suspected arbitrariness - is the enemy of credibility with regard to environmental assessments. This applies in particular when the assessment is also to be used in communication with third parties such as authorities, other market participants, customers etc. It is quite obvious that an environmental assessment is of very low value in the public perception if the result depends on the appraisal of the person performing the assessment, i.e. is subjective. In this case, another assessment author would get a different result. For these reasons, it was ensured even during the conception of the Ecological Scarcity Method that it is free of subjectivity due to factors inherent in the system and thus possible arbitrariness.

In modern forms of government, it is ensured that the major powers are separated and distributed to various entities to prevent arbitrariness. The Ecological Scarcity Method works in the same way (see Fig. 1):

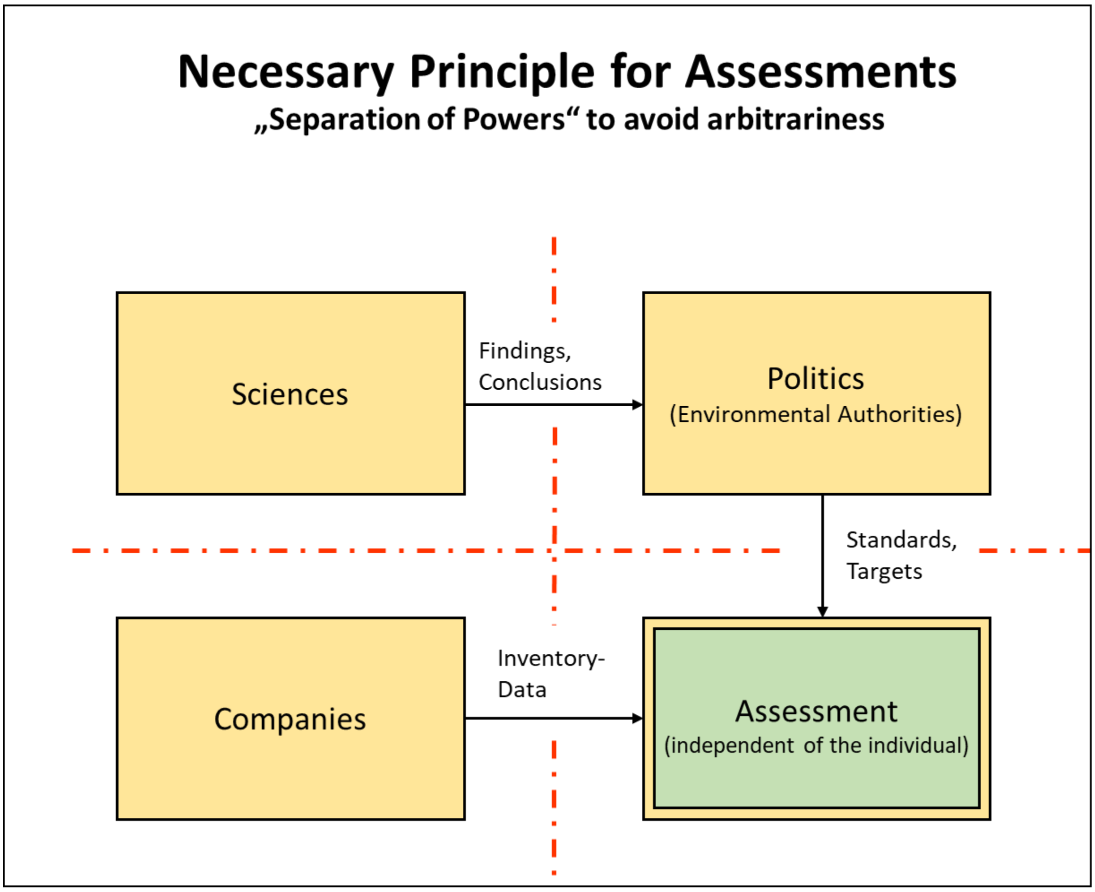

Fig. 1: Separation of powers

The sciences deliver insight into environmentally relevant contexts[1]. Politics (and/or the downstream environmental agencies, which of course also have scientists) convert this acquired knowledge into standards and objectives to provide a legitimated governmental declaration of intent. These objectives, in conjunction with the specific life cycle inventory data of the companies, then permit user-neutral, algorithmic evaluation, thus ensuring the suitability for deployment in corporations.

It is quite another matter if, for example, the person performing the assessment also selects the pollutants to be analyzed. Or if this person performing the assessment were also to specify the environmental objectives for the respective impacts, and thus also the weighting between the environmental impacts. In such a case, the result would inevitably be subjective and for third parties any form of dependability and transparency in the assertion would be lost. Such a system, by the very nature of its conception, could not prevail for business applications[2].

[1] It is also not the task of the sciences (universities, research institutes) to specify environmental objectives - at most to propose them.

[2] With regard to this question, in principle, the Ecological Scarcity Method harmonizes with other public assessment methods that have been established in society for a long time and should also deliver user-neutral results. These include, for example, the system of business accounting (with the aggregation unit of the respective currency) as well as the modern legal systems in which a 'user-neutral' result is determined within the framework of the possibilities according to specified rules with a separation of government standardization (laws) and decentralized assessment (courts).

4. REQUIREMENTS FOR THE RESULT IN BUSINESSES

As a general principle, two different use cases can be distinguished:

4.1. ASSESSMENT OF LOCATIONS AND PROCESSES WITH IN-HOUSE DATA

These are usually a company's own locations which are (also) ecologically managed and where the question arises whether over the course of time this location, possibly as regards the output, has become more ecological or not. The result is usually depicted in timelines, which means that the effect of management efforts to achieve better environmental friendliness of the location becomes directly visible. What is special about this case is that the calculation is practically exclusively carried out with in-house measured data. These include, for example, water, power, and heating oil consumption, waste volume, measured emissions in air and water etc. The assessment then precisely reflects the circumstances of this one location, provided it was possible to collate complete data. Individual processes can be considered as part of the locations here, which means that in-house data can also be collected for this.

4.2. ASSESSMENT OF PRODUCTS WITH SUPPLIER DATA OR INVENTORY DATABASE

In the case of the assessment of products, from the point of view of the assessing company raw materials, semi-finished products, assemblies etc. are usually purchased to be processed further in the company (for example on tool machines) or assembled etc. In this case, there are normally no separate data available for the purchased parts, as they have not been manufactured 'in-house'. There are two possibilities here to acquire data:

4.2.1. SUPPLIER ASSESSES USING THE SAME METHOD

Here, the sub-suppliers can provide corresponding data, which is not always easy to implement and works the better the closer the supply relationships are. Each of the companies involved in the supply chain creates an environmental assessment of their proportion of the net output of the entire product and forwards the number of eco-points per produced unit to the company that was supplied, which then collates the partial impacts of the supply chain companies and, if appropriate, also assesses use and disposal in the same way. This presupposes that the suppliers along the supply chain also create assessments using the same method and then pass on these data up the supply chain as advance performance. This is the most progressive solution to create a product assessment. By the way, similar structures exist for business costing, where the respective subcontractor also calculates their price as the total of expenses to date and passes this on to the recipient of the goods (irrespective of the theoretical additional markups for risk and profit).

4.2.2. USE OF AN INVENTORY DATABASE

Here, the use of a life cycle inventory database is the means of choice when sub-suppliers are unable to provide (adequate) data. This database contains the corresponding averaged data for the manufacture of primary materials, also for secondary (i.e. recycling) materials, processing methods, transport services, infrastructure objects, and a great deal more. These data are usually prepared for various geographical areas, usually countries, which means they can be selected. Databases of this type usually have many thousands of these entries. In this case, the manufacturing company can create the required assessments themselves for their subcontractors by means of this database and also aggregate across all third-party output along the supply chain. All that is required here is that the materials deployed and the manufacturing processes used are known, so that the matching values can be identified in the database. A requirement for this method is that the company producing the final product has to have sufficient knowledge of their subcontractors in order to achieve usable results. One advantage of this method is that the company does not have to rely on the active involvement of the subcontractors, and also gets meaningful assessments without them.

4.3. WHICH OBJECTIVES HAVE TO BE ACHIEVED?

In general, it can be said that the suitability of an assessment method depends on whether the major requirements are met in practice. In all cases, the requirements in corporations include the following:

4.3.1. COMPLETENESS

All major environmental impacts[3] should be recorded. This completeness is necessary, as consideration of only a part of the impacts would not lead to a reliable statement regarding the overall impact. Moreover, without knowledge of the weight of an impact relative to the others, optimizations would possibly be applied to a relatively 'insignificant' impact.

4.3.2. USE OF PUBLIC ENVIRONMENTAL OBJECTIVES

The public objectives of the respective leading national environmental agencies must be used. Where agencies have framed environmental objectives, these must be used, if not only for reasons related to general acceptance and compliance[4]. The endeavors of the company must not contradict this.

[3] Environmental impact = every measure that burdens the environment (for example emissions, consumption levels)

[4] Correspondence with public regulations and standards and those of the company

4.3.3. AVOIDANCE OF SUBJECTIVITY

The result must not depend on the subjectivity of the person performing the assessment. Results that depend on the person performing the assessment can hardly have appreciable in-house informative value and definitely not towards the outside world, as one question always remains: What result would have been achieved if another person had performed the assessment? Everywhere subjective appraisals of the author are included in an assessment, the reproducibility of the result will be questioned (cf. also Point 3).

4.3.4. CLARITY IN THE RESULT

The statement of the assessment system must be unambiguous. The question "What is more ecological?" must be given a clear answer by the method. The user of the method must not be expected to perform any additional assessment tasks which, for example, would require their own subjective appraisal for an overall statement.

4.3.5. RAPID RESULTS AVAILABILITY

It should be possible to determine the assessment result rapidly. The results of environmental assessments can only be used in a meaningful way in-house if they can be made in very near to real time. Here, planning or other decision-making procedures must not be delayed unnecessarily. This requirement is virtually the same as the activities involved in costing, and suggests an IT-supported method of calculation with access to corresponding databases. In this way, the susceptibility to errors in the implementation is also greatly reduced.

4.4. WHAT ARE THE ELEMENTS OF THE ASSESSMENT METHOD?

As a general principle, these include:

4.4.1. THE ASSESSMENT CRITERIA

The political environmental objectives and the current quantified environmental impacts of the national agencies responsible are determined. These are prepared for the calculation of eco-factors and serve in the method as the assessment scale (see also Appendix 2: "Requirements for assessment methods").

4.4.2. THE ASSESSMENT ALGORITHM

This includes the calculation for the assessment as well as the aggregation mechanism that makes the different environmental impacts comparable as defined by the environmental objectives, 'reducing to a common denominator' so to speak (see also Appendix 2: "Requirements for assessment methods").

4.4.3. THE REPORTING AND PRESENTATION PART

This part of the method enables preparation of the computation results in graphics and in table form and, on application of the required transparency conditions, makes them available to third parties (see also Appendix 2: "Requirements for assessment methods").

4.4.4. THE INVENTORY DATABASE

It should be possible to retrieve product and process data from this database, also for transportation, use and disposal etc. - data which are not in the organization's direct area of influence and thus cannot be measured or read off in-house (see Points 2.1 and 2.2). It is obvious that the quality of the assessment results depends to a great extent on the properties of the selected database (see also Appendix 3: "Requirements for the inventory database").

4.4.5. THE LIFE CYCLE INVENTORY WITH CORRESPONDING SPECIFICATIONS

A requirement for a meaningful environmental assessment is initially the creation of a meaningful, truthful life cycle inventory. Here, the environmentally relevant impacts and efforts for materials, energy consumption, transport etc. related to the product - or perhaps the location - are listed. The procedure for this is for the most part standardized and independent of the selected assessment method itself. The resulting items are adopted into the assessment method. (see also Appendix 4: "Specifications related to life cycle inventory").

5. ECOLOGICAL SCARCITY METHOD (ESM)

The Ecological Scarcity Method (ESM) is used here, as this is currently the only one that meets the requirements and achieves the objectives stated at Point 4. 3.

5.1. ESM PHILOSOPHY

The Ecological Scarcity Method was developed by industry for deployment in industry, i.e. in corporations. The requirements in accordance with Point 4. 3. were groundbreaking for this. Of the numerous existing environmental assessment methods, the Ecological Scarcity Method is the only method that consistently meets these requirements.

The credibility of an assessment method plays an extensive role for the user company. The following other criteria were therefore very important in the development of the present method:

a) Legitimation

Users themselves should not specify which impacts are to be analyzed as environmental impacts. For reasons related to the required neutrality, this is a matter for the respective national environmental agencies alone.

b) Definability

An initial requirement for the assessability of an environmental impact is adequate research into that impact, then knowledge of the current impact, and finally specification of a target impact, also referred to as the acceptance limit, which should not be exceeded. In other words: We must know where we stand today with regard to the impact and what the desirable state of the environment should be. If these two questions cannot be answered or not yet answered, a meaningful assessment is not possible.

c) Company influence

With correct application of the method, a company has no influence on the calculated assessment result. The company merely ensures that the assessment can be based on a complete life cycle inventory. In the process, the company can positively influence the amount of emissions and consumption in the life cycle inventory with good practice in environmental management, but not their selection or assessment criteria in the method. By the way, this also corresponds to the procedure for and approach to the creation of a business balance sheet.

d) Delimitations

The method evaluates known, researched, permitted, and planned environmental impacts. These differ from unplanned impacts, i.e. losses of process control such as leakage, explosions, accidents etc. For the latter, there are other suitable mechanisms and corresponding preventive measures to protect the environment.

5.2. PROCEDURE COMPLYING WITH ISO STANDARD

The ISO standard 14040ff. shows the recommended procedure for environmental (life cycle) assessment:

a) Definition of objective and scope of assessment

b) Creation of a life cycle inventory

c) Impact assessment (i.e. here: assessment)

d) Evaluation

It goes without saying that partial aspects can also be compared with one another, for example individual base materials, individual process steps or instead of a whole location only individual departments etc. In the same way, individual steps can be processed repetitively if, for example, a constructive solution is to be optimized. It is possible in the case of the comparison structures to acquire an orientation from the procedure for company cost accounting, for example.

5.3. THE ESM CALCULATION METHOD

The Ecological Scarcity Method permits the assessment of various environmental impacts in the context of creating products, the operation of business locations etc. These can then be aggregated to an overall value and thus made comparable.

5.3.1. AGGREGATION MECHANISM: COMPARING APPLES AND ORANGES?

The following section addresses the question of how different environmental impacts can be aggregated, i.e. merged, to one variable. In practice, this is often intuitively held to be impossible, as "apples are to be compared with oranges". However, such an aggregation is possible precisely when all the variables to be aggregated (here: environmental impacts) have an essential shared criterion that is sufficiently meaningful for the purpose of the analysis. A freight forwarder, for example, when transporting apples and oranges, would take the weight (or also the volume) of both – very different goods – which would be an adequate aggregation criterion to estimate the required transport capacity.

In the case of the Ecological Scarcity Method, this criterion for the aggregation of different environmental impacts – as the name already says – is the respective ecological scarcity.

In this context, Fig. 2 illustrates the relationships for the definition of ecological scarcity:

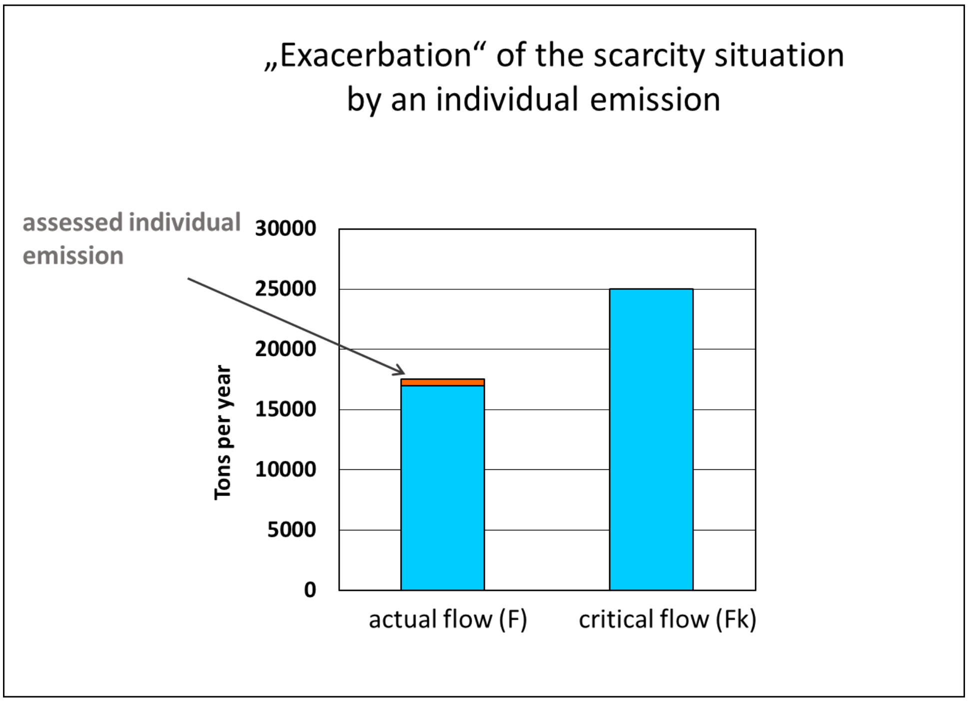

Fig. 2 Definition of ecological scarcity

Scarcity is defined as the relation between F and Fk. Expressed in a simplified form, this is the relation between 'impact' and 'capacity' of the environment. For each impact defined as a burden on the environment, an individual emission (or consumption) that is to be assessed exacerbates the corresponding scarcity situation. This relative intensification is reflected in all impact types that are analyzed in which an impact takes place. What are now aggregated, i.e. totaled, are the relative demands on the individual environmental resources with regard to the objectives of the national environmental policy. The latter are expressed by the respective scarcity situation.

5.3.2. CALCULATION OF THE ECO-FACTORS

Each country has its own environmental policy, including its own objectives and current and critical pollutant flows and consumption levels, and therefore also its own eco-factors. The objectives can be defined autonomously or 'broken down' within the framework of a larger geographical unit (for example EU). The environmental impacts for which quantitative objectives have been defined by the corresponding country are also important. These are used to calculate the eco-factors (approximately comparable with the 'harmfulness' of the impact per quantity) using the calculation in Appendix 1. There are currently the following eco-factors in calculated form:

For Switzerland:

There are currently around 50 eco-factors for different environmental impacts such as emissions in air, bodies of water, radiant emissions, wastes etc.

For the entire EU28, as well as for all 28 individual states (including UK):

There are currently 20 different environmental impacts that have been quantified and calculated to eco-factors in the required manner: As greenhouse gases, pollutant emissions in air and surface water, and various consumption levels, as well as waste.

The recalculation of the respective eco-factors only takes place when the basis for them – above all the environmental objectives and associated current releases and consumption levels - is re-assessed. This is the case approximately every five to seven years and the recalculation takes place in this context. For a better understanding and transparency, the calculation is explained in Appendix 1. More information on determining the basis for the calculation of the eco-factors can be found in:

Source for Germany: "Methode der ökologischen Knappheit", Logos publishing company, 2014
→ Link to document
→ www.syrcon-wi.de/projekte
→ New calculation of EPA-PAK16 eco-factor for Germany see Appendix 5
→ New calculation of the eco-factors "surface-waters" see Appendix 6

Source for Switzerland: Federal Office for Environment/Bern: "Eco-factors Switzerland 2021"
→ https://www.bafu.admin.ch

Source for EU28: "The Ecological Scarcity Method for the European Union", Springer publishing house
→ Link to document , www.syrcon-wi.de/projekte
→ http://www.springer.com/de/book/9783658195052
→ New calculation of EPA-PAK16 eco-factors see Appendix 5
→ New calculation of the eco-factors "surface-waters" see Appendix 6

5.3.3. REPRESENTATION OF RESULTS

As a general principle, the result of the assessment can be expressed in a single number as a total of all environmental impact points. As it makes sense that the calculation result is followed by an evaluation or optimization phase, it is also helpful to illustrate the result in graphics. Here, the analyzed environmental impacts can be shown grouped according to different criteria. For purely analytical purposes, each individual contribution, i.e. each individual impact, can also be listed as an addend to the overall result. An instructive method of representation is shown in Fig. 3.

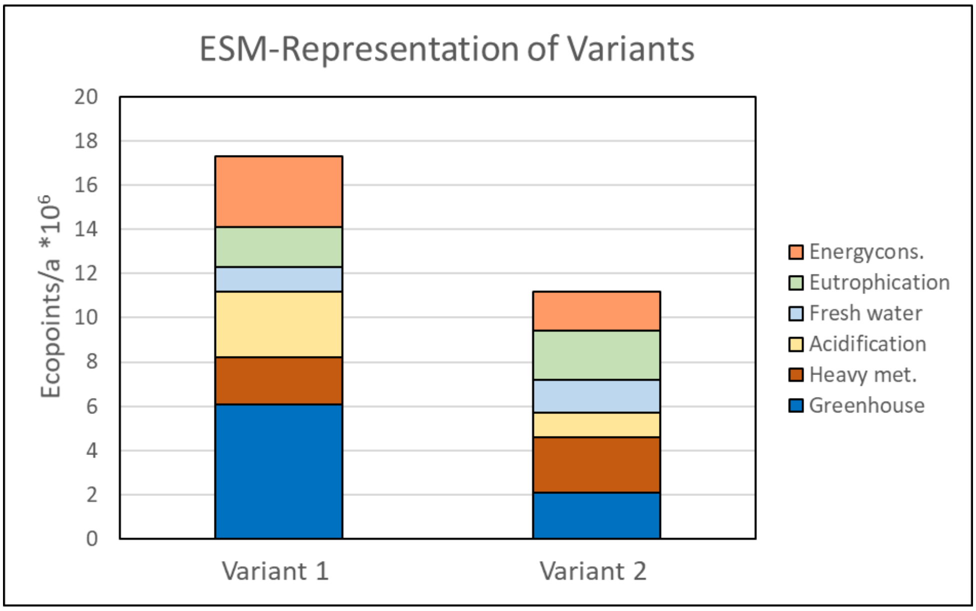

Fig. 3: Ecological Scarcity Method comparison, representation principle in the case of variant comparison

The graphic schematically illustrates a comparison of two variants with their effects on the environment: On the whole, the second variant is less of an environmental burden, although it is also not more favorable than the first for all partial impacts. The individual impacts are grouped into so-called impact categories for the sake of manageability. It goes without saying that the components of the individual impacts can also be listed separately in the same graphic as they arise from the calculation for more precise analyses. Owing to its clarity and transparency, such a representation is suitable as a reliable basis for decisions for the company using it.

5.3.4. REPRESENTATION: IMPACT-, ORIGIN- AND LIFECYCLE CATEGORIES

It is frequently the case that companies which create environmental assessments prefer a different method of representation to the summary of impacts into impact categories shown above; for management tasks and guidelines, it is often more helpful to summarize the origins of the respective impacts, for example according to plant sections (for example paint shop, assembly, packaging) or also according to suppliers, materials etc. This is often preferred because these aggregation criteria are in the direct area of influence of the company and, consequently, are also managed accordingly by one person in charge. If, then, numbers here are undesirably high, it is known whose area of responsibility is involved and how it can be changed if necessary. In contrast to this, the impact categories concern the area outside of the company in the form of impacted environmental compartments (greenhouse gases, water eutrophication, and similar) and therefore have no visible causal relationship with the respective origins and thus with the people responsible in the company. This cause-oriented analysis is therefore referred to as "formation of origin categories" and is set in this way in the data records and the calculation method. The assignment of the impacts to the corresponding origins can be defined for each company itself, as it depends on the respective specific circumstances. Likewise, an evaluation can be made according to the life phases of a product 'production', 'use' and 'disposal'. These life cycle categories are of interest above all for the overarching consideration of an entire product use - and here from the customer or societal point of view. The total of environmental impact points, i.e. the overall burden, however, is the same for all three types of analysis.

5.3.5. GEOGRAPHICAL ASSIGNMENT OF ECO-FACTORS AND DATA

The eco-factor records using the basis described here are currently available for the following countries: Switzerland, entire EU28 (as an ecologically 'managed' geographical area), as well as all individual EU states (including UK).

The following applies to the use of these country-specific assessment criteria:

If there are data records that overlap geographically, for example for Germany and EU28 the rule applies that the more stringently worded, more specific available data record should always be used. The case is different if a higher-level basis of data - in this case that for the EU28 - must be used, for example for the locations to be compared in different European countries, in order to enable comparability. It applies here that the environmental impact points of the different individual countries must not be compared with one another absolutely, as they do not have the same (quantity) basis. In Switzerland, the calculation uses the (more comprehensive) CH eco-factors.

For deliveries from a non-European country into the EU, for example, where no eco-factor record is available for the conditions there, the question arises as to how this situation should be portrayed. First of all, it has to be said that this is a fundamental question for all assessment methods. As an assessment author within the EU, the solution is to use the uniform eco-factor record for the EU28; for assessment authors in Switzerland, the national eco-factor data record is taken as a matter of principle. Deviations from the eco-factors theoretically regarded as meaningful for the non-European country with this procedure could arise above all in the case of fresh water consumption if the country is significantly more arid than the EU (or CH) average. These deviations, however, also exist within the EU between individual countries, even within Switzerland. A favorable effect is that the proportion of fresh water consumption in relation to the impact is normally rather small. Even if there were to be deviations from the described circumstances, this would only lead to shifts in the weighting among the individual impacts, but not to incorrect quantity analyses. The eco-factor records of the individual EU countries naturally take account of the different circumstances with regard to the fresh water supply.

To summarize, it can be said that: Impacts in non-European countries with eco-factors that have not yet been ascertained or might even be incomplete must be assessed as described with a known, existing eco-factor record. Even if there are constellations in which a lack of data means that not all burdens on the environment can be fully ascertained, it is still closer to the 'truth' than ignoring all impacts due to this incompleteness. For combinations of non-European and European impacts that are to be assessed, the EU28 and/or CH eco-factor records have to be used anyway on account of the necessary joint assessment basis.

5.3.6. CO2 FOOTPRINT: AN INDIVIDUAL FACET IN THE ESM

The 'carbon footprint' according to the greenhouse gas protocol is an individual environmental impact in the ecological scarcity method. As such, it can be read out separately from the Ecological Scarcity Method results and compared with other CO2eq results. It must be pointed out at this juncture that an isolated analysis of the CO2eq emissions (eq = plus equivalent in accordance with Kyoto protocol) cannot provide information regarding the overall environmental impacts of the product, of the process or of the location. In Switzerland, CO2 is one of approx. 50 different defined Ecological Scarcity Method environmental impacts; in the EU it is one of 20. This means that – depending on the object examined – significantly greater burdens on the environment can arise due to the other impacts (individual or on the whole).

5.3.7. SYSTEM LIMITS AND THE AVOIDANCE OF DOUBLE COUNTING

Depending on the use of the assessment method for products, processes, and locations, various frames of reference, i.e. system limits, are usually selected.

It is usual and systematically correct that impacts associated with the product such as producing the raw materials, manufacturing, use, and disposal are taken into account for product comparisons. For process comparisons, the system limits should be set in such a way that the same effect (i.e. output) is achieved. In the case of location analysis, the 'glass dome' principle applies, i.e. only impacts that arise at this location are examined. The following is important here:

In the case of the purely greenhouse gas analysis in line with the 'Greenhouse Gas Protocol', the greenhouse gas emissions that arise during generation of 'used energies' (in 'Scope 2') outside of the analyzed location are allocated to the location. The application of this breakdown would lead to a double assessment of the corresponding greenhouse gas emissions in the case of the holistic assessment of a location, as these are already counted in a separate location assessment at the place they arise - in the power station, for example. To prevent this, of the 'used energies' in accordance with 'Scope 2', only the energy consumption levels themselves (i.e. the scarcity aspect without the emissions which arise at other locations) at the analyzed location are therefore allocated, as these consumption levels occur within the analyzed system limits. The other impacts of 'Scope 2' and 'Scope 3' refer to other locations with their own location assessment and are counted there.

Experience has shown that the assessments for locations, processes, and products are used to deliver usable objectives and the basis for decisions to the management of, for example, a company. For entire corporations (in the sense of Scopes 1–3 of the greenhouse gas considerations according to the 'Greenhouse Gas Protocol') on the other hand, there is first of all the difficulty of the above-mentioned double assessments with upstream companies from Scope 2 and 3 as a systematic problem. In addition, this results in a combination of extensive cross-location and/or cross-company survey overhead and uncertainty regarding the variables to be attributed.

From a management perspective, such an assessment therefore leads to few direct benefits with regard to areas of responsibility and optimization potential. In this respect, the result as such cannot be 'managed' directly. Locations and products, on the other hand, are 'managed' directly, have assigned persons responsible, and this leads to benefits with the corresponding objectives.

A remark in this regard: It is of course possible nonetheless to set the system limits in this regard in line with the Greenhouse Gas Protocol if this is regarded as helpful for internal purposes, for timelines that have already begun, for example. The corresponding external emissions would then be included in the count for the location. However, there has to be clarity with regard to the above systematic analysis with the double counting and the possibly associated systematic vulnerability has to be accepted[5]. This is not recommended for the reasons stated.

[5] In other words, it can be said in principle: The total of all location impacts must correspond to the overall impact (of a geographical area, for example). In the case of the above-mentioned double counting, however, this would be higher than the overall impact, which leads to a logical contradiction.

6. AS ASSESSMENT STANDARD: 'ECO-SCOUT'

As already described above, companies rely on creating reliable assessments. This is necessary for management of the respective activities not only in the economic area, costing for example, but also in the environmental area, creating corresponding product comparisons or location assessments for example. In all cases, the assessment results should be reproducible and also comprehensible to third parties. This requires a standard for the assessment.

6.1. SAME RESULTS WITH THE SAME QUESTION

A major aim of the necessary standard is the effect that the same assessment result is produced for the same respective question. This is independent of the person commissioned with the assessment. The same is also found in the case of creating a business balance sheet, where the result must not be dependent on a single person, i.e. the accountant.

6.2. STANDARDIZATION MEASURE: IMPLEMENTATION IN SOFTWARE

Nowadays, a functioning management instrument is usually based on a suitable software solution because of its appropriateness to the business. In general, this is intended to ensure the following:

- Structuring of the workflow
- Ensuring completeness
- Avoidance of technical errors
- Ensuring a uniform standard
- Support for analysis options
- Facilitating archiving
- Connection with other workflows and assessment processes
- Links to databases, and a great deal more

The eco-scout standard implements the considerations used to date in software that is closely related to practical application. Here, 'eco-scout' is an acronym for 'ecological scarcity outcome'.

Eco-scout is not special software, rather the underlying assessment standard.

The eco-scout standard ensures that a number of requirements are set for an assessment method fundamentally to perform the described tasks. These can be found in Appendix 2.

For an environmental assessment to be performed, a company, for example, first creates a life cycle inventory that corresponds to the usual requirements and guidelines, as well as the specifications in Appendix 4 that are the same for all assessments. The basis of the assessment already includes the official environmental conditions, objectives, and specifications through the respective national eco-factors set in the system.

6.3. INVENTORY DATABASE 'ECOINVENT'

As already described at Point. 4.4.4, data from an inventory database are usually required for impacts created along the supply or disposal chain. The quality criteria for this can be found in Appendix 3. The Swiss inventory database 'Ecoinvent' has currently been found to be suitable for use in the eco-scout standard. With regard to the requirements, it corresponds to the quality criteria used as basis. In general, when using data from databases, high quality in this regard must be ensured over the long term. The use of possibly unsuitable or unchecked data has a direct effect on the assessment result and thus on the dependability of the entire assessment.

Country-specific assignment of the individual impacts:

Ecoinvent has a very large number of subentries, for example per material entry. These data are prepared for the eco-scout standard in such a way that all the relevant subentries (and only these) that exist for this are assigned to the respective environmental impacts of the country concerned and included in the calculation of the environmental impact points.

Simplification of the data access:

The reliable and rapid finding of entries in a database perhaps does not belong directly to the assessment standard to be specified, but it definitely is part of support for the above-mentioned software objectives - and thus for rapid and error-free operation. An essential simplification in the context of creating the eco-scout standard involves modifications to the database that make it easier to find and access the data. This includes translation of the original English database language into German. The database entries were also categorized, dividing the available overall stock of data according to various criteria, for example primary materials, secondary (i.e. recycling) materials, transports, processing operations etc. This categorization helps the user in searches, as does a self-learning search engine that no longer unconditionally requires the exactly correct syntax of the searched entries.

6.4. USE AND GEOGRAPHICAL REFERENCE

6.4.1. POSSIBILITIES FOR USE

The ecological scarcity method determines – in simplified terms – the burden on the environment against the background of public objectives. This is quite obviously conditional on these also being worded in a suitable manner (cf. Points 4.4.1 and 5.1.b). Environmental impacts that are only purportedly harmful or where harmfulness has not yet been included in official regulations in any way cannot and should not be taken into account. It must be emphasized once again that a normative specification of the ecological scarcity in this manner, i.e. from actual state and target state (as environmental objective), must remain a matter for the respective national authorities. Their task consists of, among others, developing such national target specifications - thus also for corporations - preparing them accordingly, breaking them down into stages where necessary, as well as following up on their implementation, and checking where applicable.

The existing eco-factors cover the major environmental impacts, which are associated above all with industrial production and with the consumption of different types of energy. It goes without saying that other impacts can be prepared for eco-factors over time if the corresponding requirements exist as described above.

6.4.2. GEOGRAPHICAL REFERENCE

The Ecological Scarcity Method takes its orientation from the ecological objectives specified for the respective country. These usually concern the entire country and are at least currently not yet regionalized, i.e. broken down to individual regions. This means that, with an existing life cycle inventory, a production facility – independently of the geographical location – has the same burden on the environment in environmental impact points per year everywhere in the corresponding country. The situation is similar with practically all other national environmental specifications such as emissions regulations, exhaust gas regulations for motor vehicles, standards for domestic fuel etc. As a general principle, however, there is a difference in effect depending on whether an emission occurs in a thinly populated area without other emitters nearby or, for example, in a densely populated area with an already high sustained impact. This geographical differentiation, which is certainly desirable later, naturally affects not only the ecological scarcity method, but rather all ecological assessment methods and approaches.

As it has been applied to date, the Ecological Scarcity Method is to be distinguished from environmental impact assessments (EIAs). The latter are intended to check specifically the ecological conditions in the sense of an individual assessment for one production facility or similar precisely for that location and to provide verification of the expected consequences. In this respect, the Ecological Scarcity Method cannot and should not replace a necessary EIA, rather both methods supplement each other. As a general principle, of course, the ecological scarcity calculation method can be used within the framework of an EIA if and to the extent that regionalized eco-factors can be specified precisely for the location to be analyzed or ad hoc (for this assessment).

6.4.3. ECO-SCOUT AS STANDARD FOR SUPPLY CHAINS

Most corporations have suppliers that provide advance performance in various ways. These can be: Materials, semi-finished products, assemblies, transport and other services, and a great deal more. If, for example, the environmental impact of a product is to be calculated, the environment data of these types of advance performance might be required. One way already described to achieve this is to use an inventory database. A significantly more elegant possibility is to involve the sub-suppliers from the supply chain in the assessment method according to the same standard. This enables the sub-supplier to pass on the ecopoints associated with the production of their goods if the calculation has used the same principles.

This means that the number of ecopoints per kilogram is passed on to the customer in a similar way to the price per kilogram of material. This gives the supplier the possibility to include the environmental impacts caused by their delivery directly in the calculation of the environmental impact of the finished product. From the point of view of the company that creates the product assessment on the whole, this results on the one hand in the possibility to recognize and purchase 'environmentally favorable' advance performance, as well as to optimize their own product ecologically. The company providing the advance performance can also be actively included in environmental strategies in such a way that there is transparency regarding the requirements and the corresponding assessment of the respective advance performance in the final product.

6.4.4. ECO-SCOUT: REGISTRERED TRADE MARK

Registration of the 'eco-scout' trade mark for the EU and Switzerland serves to protect the uniform assessment standard. This means that assessment methods and software solutions can only claim compliance with this standard if the criteria listed here have actually been met. The brand will be non-commercially licensed if these requirements are present and verified.

eco-scout®
ecological scarcity outcome

APPENDIX 1: CALCULATION OF ECO-FACTORS AND ECOPOINTS

The burden on the environment due to each impact (i) consists of the product of the eco-factor (i.e. the specific environmental impact; it could also be described as 'degree of environmental harmfulness') and the corresponding emissions level or consumption quantity.

$$EP_i = EF_i \cdot m_i$$

Where:

EP	= environmental impact in ecopoints (unit for the environmental damage)
EF	= eco-factor (unit for the environmental harmfulness)
m	= quantity

For each environmental impact analyzed in accordance with Point 5.3.2, the eco-factor is determined as follows[6]:

$$Eco-factor = K \cdot \frac{1}{F_k} \cdot \frac{F}{F_k} \cdot c \left[\frac{EP}{Unit}\right]$$

Where:

Eco-factor (ÖF)	=	Measure for the damage of an emission or consumption in ecopoints per unit (for example in g or KWh)
K	=	A characterization factor that permits, if required, the grouping of pollutants that have the same effect (otherwise = 1)
EP	=	Ecopoints (unit for the environmental damage)
F_k	=	Critical annual flow (as target formulation for the geographical area)
F	=	Current annual flow
c	=	Constant 10^{12}/a, serves to prevent high negative powers of ten

Note:
In the literature, a slightly different representation of the formula is frequently used, but with the same result:

$$Eco-factor = K \cdot \frac{1 \cdot EP}{F_n} \cdot \left(\frac{F}{F_k}\right)^2 \cdot c$$

Where: F_n = normalization flow

[6] Cf.: Ahbe et al.: "Method of ecological scarcity for Germany", Logos, Berlin, 2014, or Frischknecht et al.: "Method of ecological scarcity, eco-factors 2006" Federal Office for Environment, Bern, 2009

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> This formula notation arose through a simple, mathematically equivalent transformation (by expanding the fraction with F). The reason for this is the desire to run the normalization visibly at the variable F and/or F_n (with use of the national releases, F_n corresponds to the value F). Although this notation leads to the same result, it is slightly intellectually misleading: Firstly, the value F is a transient value that changes continuously and is therefore not very suitable for normalization purposes. The value F_k, on the other hand, is a defined, constant value and is therefore more suitable. Secondly, use of the value F for the normalization (instead of F_k) mathematically changes the intended linear and plausible functional correlation between the eco-factor and the quotient F/F_k.

The following applies to the burden on the environment from an impact

$$UBP \;=\; eco - factor * quantity$$

The ecopoints (EPs) can now be added for all (i) impacts to create a total, indicating the entire environmental impact of the location, of the process or of the product.

$$UBP = \sum_{i=1}^{\dots} (\ddot{O}F * M)i$$

APPENDIX 2: REQUIREMENTS FOR ASSESSMENT METHODS

HIGHER-LEVEL OBJECTIVES

1. Correspondence with official objectives and specifications
2. System contains all major environmental impacts
3. Method rules out subjectivity to prevent arbitrariness
4. Method creates a clear, system-supported assessment statement
5. Assessment should be able to run as IT-supported

SYSTEM REQUIREMENTS (n = necessary, d = desirable)

1	Assessment takes place in line with national official environmental objectives	n
2	Basis of the assessment at Point 1: Update approx. every 6–8 years	n
3	Use inventory database adequate for the objective (see separate requirements)	n
4	An evaluation section of the method supports the quantitative assessment and visualization of the result	n
5	Various evaluation types such as diagrams, tables, references to basic data etc. should be possible	d
6	Enable impact categories and origin categories level optionally, individual and aggregated	d
7	Implement default settings for specifications related to life cycle inventory	n
8	Compliance with the usual data protection rules required	n
9	Usual log protocol for authorship of changes	n
10	Where present: Country-specific assessment data records can be selected	d
11	Type and versions must be declared: For software, data record for environmental objective, inventory databases etc.	n
12	All inventory data must be declared on the output	n
13	The assessment framework, i.e. the selected system limits, must be requested and declared	n
14	Declare assumptions used (number of uses, km, circulations etc.)	n
15	On output: Specify author by name with date (similar to techn. plan header)	n
16	Assessment and calculation algorithms must be transparent	n

APPENDIX 3: REQUIREMENTS FOR THE INVENTORY DATABASE

HIGHER-LEVEL OBJECTIVES

1. Complete transparency of the data survey
2. Neutrality, orientation to scientific principles
3. Independence from industrial interests
6. Currentness of the database
7. Support for users

SYSTEM REQUIREMENTS

1	Regular update: The database must be updated regularly; an annual frequency is recommended, whereby a sequential procedure should be used; data records should not be older than 10 years.
2	Regular supplements to the data: The database must be continued and kept at an appropriate status as regards content in order to support technological developments, changing economic circumstances, and new assessment methods.
3	Annual database extract: The database must provide a database extract on a fixed cutoff date to ensure that the data do not change for the assessment during regular operation.
4	Regular check of transparency: The data must be checked by independent reviewers for transparency and adequate documentation. The reviewers must be mentioned by name.
5	Unrestricted access to data: The data used must be accessible to all interested users without restriction.
6	Target: Machine readability of the data; Data records must be present in an established data format and suitable for information technology processes.
7	Appropriate support for users: Users must be able to find or call up suitable information for fundamental questions.
8	No black boxes for data: Data must be viewable and usable transparently as uniform processes. Aggregated inventories / life cycle inventories alone must not be used as placeholders.
9	Possibly in the event of data gaps, offer support for analogy determinations, e.g. replacement of a missing plastic by related and/or similar plastic
10	Necessity of declaration: Always specify the source DB and version during use.
11	Clear declaration for use of 'own data': Clear separation between autonomously created data and the database data.
12	Declaration of the data origin, also indirectly: Data sources must always be specified.
13	Database variants, i.e. various possible approaches and assignment within a database, should not be a choice (no option, "Recycled Content Cut-off"). If so, then with unambiguous declaration.
14	No mixed use of two or more DBs for the purpose of database hopping within an assessment. If it should be necessary for reasons of availability, only with unambiguous declaration.
15	The database does not have to contain 'all' areas. That means there can be a focus on individual or a number of areas.

APPENDIX 4: SPECIFICATIONS RELATED TO LIFE CYCLE INVENTORY

HIGHER-LEVEL OBJECTIVE

Essential specifications on creation of a life cycle inventory should be homogenized to favor trustworthiness and comparability of the results.

Decisive principle

Although not all cases that occur in practice can be determined in advance and linked to generally applicable rules, this is possible for the major cases. Important here is to create transparency with the corresponding declarations. This enables environmental assessments created by third parties to be checked for plausibility and kept free for the most part of possible arbitrariness.

1. ALLOCATIONS RECYCLING

Preliminary remark: The European Commission recommends in the 'Environmental Footprint Category Rules' (PETCR, Vers. 6.3-2, 2017) various approaches to an allocation of the environmental impact of recycling material to new material (and also very similar the ISO standard 14044). These go from (as a percentage) 20/80, through an 'equilibrium 50/50', up to an 80/20 allocation. The proportions here for the recycling material should be specified depending on supply and demand, i.e. ultimately according to economic criteria.

With regard to the approaches to modeling, it must be stated that there is no absolutely 'correct' relationship for the allocation. It is much more the case that especially in the context of use of the data in corporate environment management there are demands for

- Support for objectives
- Plausibility
- Homogeneity (all users do it the same way) and
- Avoidance of double counting

The allocation that is ultimately selected and used will thus have a significant governance effect. In the case of a generally envisaged recycling economy, for reasons related to plausible causality – from a strictly ecological point of view – the generation of potentially recyclable materials should not be assigned a credit. An incentive also desired in the PEF rules (see above), e.g. to give preference to manufacturers of recyclable materials, is encouraged more due to market economy oriented considerations: Recyclable materials are more in demand on the market than non-recyclable materials, as the latter generally do not have a residual value after first use. The motivation for recycling should be to reuse existing materials (also energies), thus creating a mathematical ecological advantage in that now only the processing with the corresponding environmental impacts is necessary and consequently allocated. The described market economy oriented incentive for the use of recycling material supplements the ecological advantage without diluting it due to an overlap with economic aspects.

Choice within the framework of the assessment objectives:

Cut-off approach: For the pure provision of recyclable materials, no ecological credit is granted yet. However, if recycling materials (in recycled form) are used in production, only the environmental impacts during the processing of these recycling materials and/or the corresponding material proportion are taken into account; the recycling materials themselves are then impact-free, as these impacts have already been allocated on manufacture of the new material.

A remark in this regard: The UBA (D) recommends for German circumstances in the case of 'open-loop' recycling to orient towards the corresponding BMU/UBA survey: "Ecological balance for beverage packaging, 2002, Appendix 2" (based on Klöpffer, Walter: Allocation Rule for Open-Loop Recycling in Life Cycle Assessment. In: Int. J. LCA 1 /1/ 1996, pages 27–31) and to perform a 50/50 allocation.

2. Allocations in the case of by-products

Preliminary remark: ISO standard 14044 envisages a scaled analysis for the topic of 'allocations in the case of by-products'. This goes from the organizational part of the process (where possible), through the identification of divisible relationships related to content, all the way to using the product values or other properties as corresponding allocation criteria.

Economic product values have the disadvantage for ecological assessment purposes in entrepreneurial decision situations that counter-intuitive assessment situations can arise that have a lack of visible plausibility. However, the latter is decisive for acceptance and the broad deployment of assessment methods and data in corporations.

Choice within the framework of the assessment objectives:

By-products that arise in combination with a primary product are environmentally neutral in the assessment if their environmental impacts have already been completely allocated to the primary product. In the case of two or more products of equal rank, a corresponding division can take place. If applicable, there is a corresponding credit.

As an alternative to this: Economic allocation the same as the mixed costing in business management, i.e. value-based allocation. Depending on the defined question, other allocation bases could also be expedient (value, energy content, protein content etc.). This presupposes that the corresponding databases provide the information necessary for this. This could be done at a later point in time.

3. Scope of assessment for locations, products, processes, and companies

a) Locations

The assessment of entire locations takes place in such a way that all the impacts associated with the immediate location (for the assessed location including the company vehicle fleet: all emissions, all local energy and resource consumption levels as well as wastes) are integrated into the assessment.

These location assessments are necessary above all as management and goal setting instruments to assess the location's environmental management. For systematic reasons, it must be ensured that no double assessments and/or double counting with the impacts of other locations take place (therefore: 'glass dome' principle). Only location sections or, in the same way, individual manufacturing processes can be assessed.

Note regarding 'locations': In the case of the purely greenhouse gas analysis in line with the 'Greenhouse Gas Protocol', the greenhouse gas emissions that arise during generation of 'used energies' (in 'Scope 2') outside of the analyzed location are allocated to the location. The application of this breakdown would lead to a double assessment of the corresponding greenhouse gas emissions in the case of the holistic assessment of a location, as these are already counted in a separate location assessment at the place they arise. Of the 'used energies' in accordance with 'Scope 2', only the energy consumption levels themselves (i.e. the scarcity aspect without the emissions which arise at other locations) at the analyzed location are therefore allocated, as these consumption levels occur within the analyzed system limits. The other impacts of 'Scope 2' and 'Scope 3' refer to other locations with their own location assessment and are counted there.

b) Processes

The assessment of a process takes place in the same way as for the location, as it can be regarded as a partial location for which the same rules apply.

c) Products

For assessments of a complete product, the entire supply chain, from the raw material, through any assemblies, all the way to the finished and packaged product, including logistics, must be taken into account. In addition, the impacts arising during use over the entire service life, including disposal, are included. It goes without saying that partial analyses are also possible, for example of individual assemblies, of disposal variants, of logistics alternatives etc.

d) Entire corporations

Preliminary remark: Experience has shown that the assessments for locations, processes, and products are used to deliver usable objectives and the basis for decisions to the management of, for example, a corporation. For entire corporations (in the sense of Scopes 1–3 of the greenhouse gas considerations according to the 'Greenhouse Gas Protocol') on the other hand, there is first of all the difficulty of the above-mentioned double assessments with upstream companies from Scope 2 and 3 as a systematic problem. In addition, this results in a combination of extensive cross-location and/or cross-company survey overhead and uncertainty regarding the variables to be attributed. From a management perspective, such an assessment therefore leads to few direct benefits with regard to areas of responsibility and optimization potential. In this respect, the result as such cannot be 'managed' directly. Locations and products, on the other hand, are 'managed' directly, have assigned persons responsible, and this leads to benefits with the corresponding objectives.

For these reasons, assessment for entire corporations are difficult to delimit due to the overlaps.

In what is 'correct' from a systematic perspective, company assessments should consist of one (or a number of) location assessment(s) with associated product assessments for the upstream reference services (according to Scopes 2 and 3) and the downstream value chain (according to Scope 3). In all cases, the system limits used as the basis for the assessment must be declared precisely in order to ensure comparability.

4. Energy mix to be used as basis

a) Domestic

The standard for domestic consumption levels is the average domestic power consumption mix.

Important here is that evidently the power consumption mix is usually not identical to the power production mix.

b) Cross-national

A supplied product can consist of different materials, components or assemblies that are manufactured in different countries. In the case of this type of cross-national consumption and supply chains, there are a number of aspects to bear in mind: Availability of the country-specific data, necessary proofs of origin, as well as a speed of calculability suitable for industry.

Choice within the framework of the assessment objectives:

In the case of such a constellation, the above points currently point to using the geographically higher assessment level of the EU28 basis (power mix and assessment parameters), i.e. the average European power mix. This stipulation should apply if there are no deviating national specifications or authority usages (for example Switzerland).

The specifications at a) and b) are oriented to the calculability and also to the fact that in communication with third parties no individual energy configurations (here: of national origin) can usually be guaranteed. With another specification, a substitution effect would arise, as not all interested parties can obtain energy from the most ecologically favorable individual supplier and there is therefore automatically a balancing across the large number of providers (this purely on the supply side and also as regards price). If special forms of energy or mixes are be taken into account for individual supply chain assessments, this is possible and must be declared precisely. In the case of the environmental impacts for example due to energy consumption, there is normally no allocation to the ownership structures with regard to the energy generating facilities, rather to the use of scarce public goods such as air, water, resources etc. In other words: The acquisition of property as an economic activity, for example a renewable energy system, does not change the result of an environmental assessment yet, provided the corresponding factual domestic power mix does not change.

5. Transparency and procedural rules for constellations that have not yet been specified

Preliminary remark (also applies to the following items 5–11): The use of primary and/or foreground data should be aimed for. It is good scientific practice to justify and document assumptions and specifications. In the same way as the generally accepted accounting principles, the rules of balance sheet truth, clarity and continuity must also be complied with in the case of environmental assessments.

For all cases that cannot be handled with the standardized process steps, the underlying assumptions and specifications must be declared precisely.

6. Procedure in the case of missing data

In the case of in-house surveys, missing data can be replaced (temporarily where possible) with estimates and plausible assumptions.

Missing material data, in a database for example, can be replaced by analogies (i.e. similar existing data) based as closely as possible on practical application. In both cases, it is definitely better to replace the data gaps with these approximations than to ignore the data completely because of a lack of more exact knowledge. In all cases, there must be a precise declaration of the corresponding approximate assumption. In addition, where present, benchmark data from public databases can be used, also with the corresponding declaration.

7. Rules for disposal assessments

In the case of disposal, the usual average disposal paths of the relevant country are used as the basis. The disposal parameters here are country-specific and/or to be selected on EU28 level (see Point 4).

The proportion that is returned to the material suppliers (for example as punching waste for recycling) is not waste in the ecological sense and is credited in the impacts. Disposal variants that deviate from the usual path must be declared accordingly.

8. Service life declarations

Service life specifications (such as miles/kilometers traveled, number of circulations, number of uses etc.) that are included in the assessment must match the actual circumstances, be specified exactly, and above all made transparent in communication with third parties. If comparative surveys with different service life data are carried out, this is to be specified explicitly.

9. Cut-off criteria for assessments

For the assessments, these are to be set in such a way that no unnecessary calculation and survey overhead is required if the influence on the result is too minor. A requirement for calculation accuracy that is too deep has a prohibitive effect due to the rapidly rising overhead for environmental assessments.

A proven benchmark for this can be orientation to the procedure for usual cost accounting.

10. Declarations of the use of in-house data and database data

In order to achieve credibility and transparency of the assessment, the data that are used must be specified. These can be foreground data (usually gathered in-house) or background data (from a database). In all cases, the corresponding sources must be specified and declared.

More details regarding the use of databases can be found in the corresponding requirements list for databases.

11. **Annual comparisons as a timeline**

In order to enable a meaningful interpretation of the results, neither the database version nor the assessment criteria should changed within timelines (e.g. over a number of years); the basis for assessment that is used, however, must be declared. Timelines should therefore always be calculated with the same data records (concerns database data and eco-factors), better still with the latest ones available. For reasons related to transparency, the data records should be declared accordingly.

12. Long-term emissions

Emissions that only enter the environment a long time after manufacture of the products and/or materials are not taken into account in the assessment (e.g. washing heavy metals out of slag or excavated material that occurs during manufacture of a product and are washed out over millennia).

As regards content and the temporal assessment horizon, these 'long-term emissions' do not fit in with the underlying frame of 'annual releases'. A possible solution to this unsatisfactory situation is to take account of 'long-term emissions' proportionally. Here, a write-off solution would have to be used in a suitable manner over the duration of the expected emissions. These are currently not yet available in the pertinent databases, but can be integrated in a new database version at a later point in time. The long-term emissions should therefore only be considered with the corresponding defined questions.

APPENDIX 5: RECALCULATION ECO-FACTOR "EPA-PAK16"

Initial situation

In the publication "Method of Ecological Scarcity for Germany (ÖkoF-D)"[7] the eco-factors were collected as evaluation criteria for environmental assessments for Germany. Among the 20 eco-factors (EF) determined is that of "EPA-PAH16" for discharges to surface waters. Practical application has shown that the calculation procedure for this eco-factor should be reviewed on the basis of more recent findings. This is to be done without changing the underlying environmental objectives and the collected mass flows.

The eco-factor "EPA-PAH16" was determined in EcoF-D as the sum value of 16 individual PAH values[8] under the lead substance benzo(a)pyrene (BaP). In order to simplify the calculation, it was assumed that all of these individual values behave in a similarly polluting or toxic manner as the lead substance BaP. It was known that BaP - compared to the other 15 values - has a significantly higher toxicity. This was noted in the ÖkoF-D study as follows (p. 50):

"The use of benzo(a)pyrene as a lead substance for the EPA-PAH16 eco-factor target definition tends to lead to a relative overestimation of the adverse effect. However, in view of the data situation for the individual substances, which can still be improved, and the described harmful potentials, this is considered acceptable here."

Subsequently, however, it became apparent that this was accompanied by a significant overestimation of the toxicity of the total sum value, which could lead to an implausible comparative overaccentuation of EPA-PAH16. In the present paper, this relative calculation-related overestimation of the 15 individual PAH values compared to BaP is to be reviewed and corrected accordingly.

Calculation

For this purpose, the average share of BaP in the entire EPA-PAH16 substance group must first be determined and then the other part with a lower toxicity to be determined must be weighted via a characterization factor[9].
In EcoF-D, the eco-factor for EPA-PAh16 is calculated from the value pair:

- current flow F: 19.16 to/y. (annual emission of all 16 individual values, 2005-2008)
- critical flow Fk: 4.41 to/y. (annual target load, with critical value for BaP)

[7] ÖkoF-D: Ahbe, S., Schebek, L., Jansky, N., Wellge, S., Weihofen, S. (2014): Methode der ökologischen Knappheit für Deutschland - eine Initiative der Volkswagen AG, Logos-Verlag Berlin GmbH, Berlin.

[8] Benzo(a)pyren, benzo(g,h,i)perylen, benzo(k)fluoranthen, fluoranthen, indeno(1,2,3-cd)pyren, benzo(b)fluoranthen, naphthalin, acenaphthen, acenaphthylen, fluoren, anthracen, phenanthren, pyren, benzo(a)anthracen, chrysen und dibenzo(a,h)anthracen

[9] A similar approach is used to determine the eco-factor for CO2eq, for example, which uses characterization factors to take into account the significantly higher greenhouse effect of substances that have the same effect as CO2, such as methane (characterization factor: 24).

First, it is determined how the current flux is divided between the proportions of BaP and the other 15 PAH values. With reference to Scheffer & Schachtschabel[10], Fuchs et al.[11] give a rough approximation with a ratio of 5% to 95%. A comparison with the ratios for Switzerland shows a similar picture[12]. With these values, the corresponding distribution results in the following loads:

- benzo(a)pyrene: 5% of 19.16 to/y = 0.958 to/y.
- 15 residual PAH substances: 95% of 19.16 to/y = 18.2 to/y.

The differences in toxicity for the present case can be estimated with good approximation reciprocally from the ICPR[13] target concentration ratios for the two fractions as follows:

- ICPR target for benzo(a)pyrene: 0.01 µg/l -> characterization factor K = 1
- ICPR target for sum PAH: 0.1 µg/l -> characterization factor K = 0.114

A study by BLGL[15] for different emission sources also makes this ratio of toxicities seem plausible. The following calculation gives the resulting eco-factor with these characterizations:

$$EF = K \cdot \frac{1 \cdot EP}{F_k} \cdot \frac{F}{F_k} \cdot c$$

$$EF = \frac{1 \cdot EP}{4.41\ kg} \cdot \frac{(18.2 \cdot 0{,}1 + 0.958 \cdot 1)\ kg}{4.41\ kg} \cdot 10^{12}$$

$$EF = 142.842{,}0\ \frac{EP}{g}$$ for EPA-PAH16

[10] Scheffer, F., Schachtschabel, P. (2002): Lehrbuch der Bodenkunde, Spektrum Akademischer Verlag; Auflage: 15. A.

[11] Fuchs, S., Scherer, U., Wander, R., Behrendt, H., Venohr, M., Opitz, D., . . . Götz, T. (09 2010). UBA-Texte 45/2010: Berechnung von Stoffeinträgen in die Fließgewässer Deutschlands mit dem Modell MONERIS. Dessau-Roßlau: Umweltbundesamt (UBA).

[12] For Switzerland, the corresponding proportions for 2013 were 4.6% to 95.4%. (Source: Frischknecht R., Büsser Knöpfel S., 2013: Ökofaktoren Schweiz 2013 gemäss der Methode der ökologischen Knappheit. Methodische Grundlagen und Anwendung auf die Schweiz. Bundesamt für Umwelt, Bern. Umwelt-Wissen Nr. 1330

[13] ICPR, International Commission for the Protection of the Rhine: "Comparison of the Current Status with the Target Status of the Rhine 1990 to 2008", report No. 193, 2011.

[14] In contrast to the CO2 situation, the characterization factors here are smaller than 1 because the other substances are less toxic than the lead substance BaP.

[15] Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit: „Prüf- und Maßnahmenwerte für polyzyklische aromatische Kohlenwasserstoffe (PAK) Stand: Oktober 2014“, p. 4

The eco-factor from EcoF-D is thus reduced from 985,186.0 UBP/g to 142,842.0 UBP/g. This is also understandable in terms of content, since 95% of the total load of PAHs is now included in the calculation with an average toxicity ten times lower than that originally used as a basis. Until the next update of the total set of eco-factors for Germany, this new value will therefore be used.

Recalculation for EU28

The calculations of eco-factors for EPA-PAK16 for the EU28[16] are based on the determination of the corresponding German value. They are therefore adjusted in the same way. As with the German eco-factor, the conversion factor is composed solely of the two freight shares and the associated weightings (characterizations), i.e. the following values:

$$\text{Conversion factor} = 0{,}95 * 0{,}1 + 0{,}05 * 1 = 0{,}145$$

Therefore, all EPA-PAH16 values calculated in the publication must be multiplied by the corrective conversion factor of 0.145.

SYRCON, 10/13/2021/ Stephan Ahbe

[16] Ahbe, S. Weihofen, S., Wellge, S.: The Ecological Scarcity Method for the European Union, Springer 2018

APPENDIX 6: REVIEW AND RECALCULATION OF THE ECO-FACTORS "DISCHARGE TO SURFACE WATERS" FOR GERMANY AND THE EUROPEAN UNION

A. Initial situation

In the publication "Ecological Scarcity Method for Germany (ESM-G[17])", the eco-factors were surveyed as evaluation criteria for environmental assessments in Germany. Among the 20 eco-factors determined, there are nine that represent the ecological situation of discharges of pollutants into surface waters. Practical application has shown that the calculation procedure for these eco-factors should be reviewed on the basis of more recent findings. This should be done under priority consideration of the public environmental goals and quality criteria as well as the publicly collected pollutant loads. Two aspects are to be focused on in particular:

1. Consideration of the heavy metals lead and cadmium. For these, target values were interpolated at the time with a view to an intended ban on discharges for the year 2020. The particular challenge of determining reliable target values so close to the ban was already commented on in the report as follows:

   "With the goal of "zero" (= ban), cadmium as a pollutant would fall out of this assessment procedure, since the effective enforcement of compliance with bans is not the subject of this assessment procedure. Nevertheless, until an effective ban, cadmium emissions are still ecologically relevant in the sense described above, and an assessment is desirable in this respect. An approximate solution for this transitional period is therefore provided by the following estimate: Based on the current value for the actual load in 2013 and the target value for the year 2020 of zero, an interim target is formulated for the year 2016. This should be 50% of the current actual value of 2005 = 4.6 t/a. This value should be reviewed with regard to the assumptions made and the course of effective target achievement after a few years as part of the data update."

   The analogous formulation existed for the pollutant lead. Experience has now shown that the environmental impact points for lead and cadmium emissions were extraordinarily dominant in the assessments. This exaggeration led to the other impacts, such as air pollutants or resource consumption, being greatly reduced in relative importance. Therefore, a review and, if necessary, a recalculation based on updated sources should be carried out.

2. At that time, a general mathematical aggravation of the scarcity situation was made by an additional halving of the critical loads (= aggravation of the environmental targets). This was commented in the text of the study as follows:

   "*Target loads calculated from a total discharge are to be reduced by half again to take account of the fact that the quality targets are not met everywhere. This is done in analogy to the procedure for wastewater treatment plants: to ensure compliance with the target values of the effluent concentrations, the plants are controlled to half the target values*".

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[17] ESM-G: Ahbe, S., Schebek, L., Jansky, N., Wellge, S., Weihofen, S. (2014): Methode der ökologischen Knappheit für Deutschland - eine Initiative der Volkswagen AG, Logos-Verlag Berlin GmbH, Berlin.

Here, too, experience has shown that these values appeared to be excessive compared to air pollutants, for example, where this was not done. Therefore, this determination should also be examined and corrected if necessary.

B. Recalculation

In the following, the two aspects mentioned above are reviewed with respect to the task:

1. Heavy metals lead and cadmium

The ban on heavy metal emissions for lead and cadmium used as a basis for setting the target in ÖkoF-D in 2014 did not materialize in this way. Restrictions here relate more to process management, regulations and limits to be complied with than to a blanket overall reduction to zero. On this subject, there is a relatively long history of measures[18] and agreements to reduce these heavy metal emissions, mostly also in connection with mercury[19], which is not yet taken into account here. The present case concerns the discharge of lead and cadmium into surface waters. Environmental protection measures are usually checked by measuring the concentrations of pollutants at various measuring points and comparing them with the applicable quality target values[20].

The following values were determined in the 2014 ESM-G report, Table 1:

Germany, annual loads
Cadmium: F = 9.23 To/a Fc = 2.31 To/a
Lead: F = 263.0 To/a Fc = 65.75 To/a

with: F = actual annual flow and

Fc = critical annual flow (as target)

[18] Reduction of lead in fuels, filters in combustion plants, modernization of production processes, etc.

[19] E. g. Aarhus Protocol on Heavy Metals, 1998, amended 2012; CLRTAP (Convention on Long-Range Transboundary Air Pollution), UNECE etc.

[20] EQS, Environmental quality standard

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The German Federal Environment Agency has published the study 'UBA 2017' on the state of water bodies in 2017[21], which provides an overview of both the current annual loads and the respective degree of compliance with the environmental quality standard (see following table). For the present question, the following emerges from it:

- The pollutant cadmium was measured at approx. 183 measuring points and the EQS was complied with at 173 measuring points, five points exceeded the EQS and at a further five points the EQS could not be checked[22]. In summary, it can be said that the target values were met practically everywhere.
- For the pollutant lead, the EQS was met at all of the approximately 180 monitoring sites.

These data give a different picture than the one used as a basis in ESM-G. In this study, the critical loads (targets) were significantly lower than the current loads, which would inevitably result in a large-scale exceedance of the EQS. Since this is now obviously and fortunately not the case according to the more recent study, the following estimation - based on logical conclusions - can be made for the determination of an annual load to be regarded as critical for both heavy metals: The current annual load cannot be greater than the critical load in either case if the quality targets are met practically everywhere. How much higher the critical loads could possibly be than the current annual loads cannot be determined in either case from the available data in the study. As a lower bound, however, it can be stated that Fc = F in both cases. With this definition one is on the safe side, i.e. the heavy metals cadmium and lead are certainly not underestimated in their relative importance to the other impacts. At most, there could be a certain overestimation of the importance, which cannot be determined at present. One of the tasks of the next update of the eco-factors would be to examine this question again and more intensively.

For the calculation of the eco-factors of cadmium and lead, this results in the following values for Germany in Table 2 below:

$$EF = K \cdot \frac{1 \cdot EP}{F_c} \cdot \frac{F}{F_c} \cdot c$$

According to ESM-G with K = 1 and c = 10^{12} per year

(in original notation)

[21] UBA 2017: Umweltbundesamt (2017): Gewässer in Deutschland: Zustand und Bewertung. Dessau-Roßlau, p. 58/59

[22] Values read from the bar graph

Tab. 2: Comparison of eco-factors for Cd and Pb previous (from ÖkoF-D) and new with F = Fc each (from UBA 2017)

Annual loads, prev. (ESM-G)	**Ecofactors, prev. (ESM-G)**	**Annual loads, new (from UBA 2017)**	**Ecofactors, new (calc. from UBA 2017)**
Cadmium: F = 9.23 To/a Fc = 2.31 To/a	Cadmium: 1,729,728.0 EP/g	Cadmium: F = 6.8 To Fc = 6.8 To	Cadmium: 147,058.0 EP/g
Lead: F = 263.0 To/a Fc = 65.75 To/a	Lead: 60,846.0 EP/g	Lead: F = 265.0 To/a Fc = 265.0 To/a	Lead: 3,773.5 EP/g

The eco-factor from ESM-G is significantly reduced due to the previous considerations and the new data from UBA 2017. In terms of content, this is also understandable, since a situation with great ecological scarcity due to the expected ban has now been underpinned by a significantly less critical overall situation with the data from UBA 2017.

2. Pollutants P, Ni, Zn, COD, Cu, EPA-PAK16 in surface waters[23]

In ESM-G, the calculation of the critical annual loads for the pollutants P, Ni, Zn, COD, Cu and EPA-PAK16 was carried out from the national total discharges[24]. In accordance with common practice at wastewater treatment plants, a safety factor of 0.5 was included for the determination of the respective critical load, which is used to control a 'halved' target value in the process control. The reduced value is intended to ensure that the quality target is safely undercut on site.

The following can be said about the application of this principle of additional halving of the target value from today's perspective:

- When calculating the critical annual loads for the whole country, the focus is not on the individual undercutting of the quality target at each individual measuring or discharge point, but on the ratios in the average of all discharge points, since a total load is to be formed. This results by definition already without the factor 0.5.

- If the discharge of pollutants into surface waters were to be provided with an additional safety factor of 0.5 for the critical loads, then from today's point of view this would also have to be done for all other environmental impacts, such as air pollutants or consumptions, etc., since these

[23] This does not apply to the pollutant nitrogen (N), which was calculated in a different way in ESM-G and for which no further halving of the critical load was made as a result.

[24] P. 37ff.

would otherwise be systematically underestimated in their effect compared to water pollutants. The use of the factor 0.5 results in a significant over-weighting of the water pollutants (excl. N), which is neither supported by the assessment system nor justified by the environmental objectives.

Both of the above-mentioned reasons are decisive for the fact that the weighting of pollutants in surface waters was too high in the previous approach. Therefore, this safety factor is removed where it was used in order to balance the weighting accordingly.

3. Results for future environmental calculations

The eco-factors for Germany are therefore as follows (as of 06.12.2021):

Environmental impact	**Act. load**	**Crit. Load**	**Ecofactor: $EP_{GE-2018}$ per Unit**	
Emissions to air:				
CO2-eq [kt/a]	916,769	246,486	0.015	/g
NMVOC [kt/a]	1,006	826	1.475	/g
NOx als NO2 [kt/a]	1,288	652	3.03	/g
SO2 [kt/a]	445	324	4.239	/g
Particulate matter PM2,5 [kt/a]	111	79	17.79	/g
NH3 [kt/a]	563	426	3.102	/g
Emissions to surface waters				
Nitrogen [t/a]	564,800	515,550	2.125	/g
Phosphorus [t/a]	22,200	17,644	71.31	/g
Nickel [t/a]	476.8	450	2,355	/g
Zinc [t/a]	2,755	3,530	221.3	/g
COD [t/a]	490,800	529,332	1.753	/g
Leadi [t/a]	265	265	3,774	/g
Cadmium [t/a]	6.8	6,8	147,058	/g
Copper [t/a]	461.2	705.8	926	/g
EPA-PAK16 [t/a]*	19.16	8.82	35,710	/g
*) after recalculation in Oct. 2021				
Resources				
Freshwater [Mio m3/a]	32,000	37,600	22.63	/m3

Energy efficiency/-scarcity:				
Primary energy consumption [PJ/a]	13,599	7,140	-	
Renewable energy cons. [PJ/a]	1,463	2,245	0.349	/MJeq
Not renewable energy cons. [PJ/a]	12,136	4,895	0.506	/MJeq
Waste				
Waste gen., not dangerous [Mt/a]	136.82	136.82	0.0073	/g
Waste gen., dangerous [Mt/a]	15.73	15.73	0.0636	/g

C. Recalculation for EU28

The calculations of the eco-factors for the EU28 (EF-EU28)[25] are partly based on the determination of the corresponding German values for the "Emissions to Air". They are therefore adjusted in the same way as above, although the current loads (F) were also taken over for lead and cadmium from the existing derivation in ÖF-EU28.

The eco-factors for the EU28 as a unit are thus as follows (as of 06.12.2021):

Environmental impact	**Current Flow**	**Critical Flow**	**Eco-Factor: $EF_{EU-2018}$ (EP)**	
Emissions to air:				
GHG CO2-eq [Mt/a]	4,544	1,125	0.003590	/g
NMVOC [kt/a]	7,500	6,366	0.1851	/g
NOx [kt/a]	9,000	6,585	0.2076	/g
SO2 [kt/a]	5,000	3,209	0.4855	/g
PM2,5 [kt/a]	1,350	1,173	0.9812	/g
NH3 [kt/a]	3,500	3,584	0.2725	/g
Emissions to surface water:				
Nitrogen (as N) [kt/a]	6,387	5,831	0.1879	/g
Phosphorus (as P) [kt/a]	327.4	260.2	4.83	/g
Nickel [t/a]	3,472	3,278	323.3	/g
Zinc [t/a]	19,506	24,982	31.25	/g

[25] Ahbe, S. Weihofen, S., Wellge, S.: The Ecological Scarcity Method for the European Union, Springer 2018

COD [kt/a]	4,128	4,452	0.208	/g
Lead [t/a]	2,469	2,469	405.0	/g
Cadmium [t/a]	79,55	79.55	12,570	/g
Copper [t/a]	3,341	5,112	127.8	/g
EPA-PAK16 [t/a] (mit Charakterisierung)	117.9	54.23	5,803	/g
Resources				
Freshwater consumption [Mio m3/a]	270,800	623,800	0.6959	/m3
Energy efficiency/scarcity:				
Primary energy carriers [PJ/a]	70,460	61,713	-	
Consump. of renewable energy [PJ/a]	7,429	8,422	0.01917	/MJ
Not renewable primary energy carr. [PJ/a]	63,031	53.291	0.02219	/MJ
Waste				
Waste, not hazardous [Mt/a]	893.5	893.5	0.001119	/g
Waste, hazardous [Mt/a]	94.46	94.46	0.01059	/g

The values of the individual EU countries are updated and stored in the databases in the same way.

SYRCON, 12/06/2021/ Dr. Stephan Ahbe